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THE EFFICIENCY OF SECONDARY GENERATORS.

IN looking through the report of Dr. John Hopkinson on the Gaulard-Gibbs system of electric lighting, which we published last week, one cannot fail to be struck with the unsatisfactory nature of this document. It appears, as we remarked in a few preliminary paragraphs attached to the report, that Dr. Hopkinson bases his calculations on the tests which he made with a *portion* of the secondary generator which is stationed at Edgware Road. We, in our turn, will endeavour to make a few calculations based on the figures given. We find that eight of the 16 columns comprised in this apparatus were employed in giving current to 27 incandescent lamps, each said to be taking 63 volt-ampères or watts. Four of the columns supplied the necessary electrical energy for two Jablochkoff candles, each requiring 375 volt-ampères. The remaining four columns were not in use, but we will presume that they could have been actuating, say, 13 more incandescent lamps of the same kind. The Metropolitan Railway stations of King's Cross and Aldgate have each a similar apparatus for the purposes of illumination. At the time of Dr. Hopkinson's experiments all the columns of these instruments were said to be in action. It will be noticed in the report that 151 incandescent lamps, and five Jablochkoff candles, are accounted for. If the Edgware Road apparatus may be taken as an example of the others, we might actuate from this instrument 40 incandescent lamps and two Jablochkoff "arcs."

Let us assume that the same conditions existed at a second station; but, as at the third, only one Jablochkoff was in action, we might here account for 47 incandescent lamps. This gives a grand total of 127 incandescent lamps, and five Jablochkoff candles, requiring each an electrical energy of 63 and 375 watts respectively. Taking Dr. Hopkinson's figures for the loss in the main line, for the sake of argument, we get a total of 13,506 watts, which gives a total efficiency of but 80 per cent. to the secondary generators instead of 89 as published in the report. As a matter of fact, our figure agrees precisely with that derived from Dr. Hopkinson's actual test made on a portion of the apparatus, and under the most favourable conditions. But actually the main line has nothing to do with the efficiency of the generators and ought, therefore, to be left out of the question. The percentage of efficiency of the induction coils would thus be, according to our reading of the published figures, further reduced to 76 per cent. So far as we can see, there is no valid reason why the intermediate apparatus should be deemed more efficient than that stationed at Edgware Road, and if, therefore, 151 incandescent lamps were in use at the time of the tests, it means that a less amount of electrical energy than 63 watts was being consumed in the majority of cases. Indeed, the report shows that when the two Jablochkoff candles were in action, each of the incandescent lamps was consuming but 54 watts. It is not so very long ago that we were obliged to call attention to the so-called efficiency of a well-known machine which was supplying current for 1,300 lamps. From the measurements on one lamp only, it was *assumed* that the remaining 1,299 were each consuming an equal amount of energy and giving the same candle-power, when, to our certain knowledge, some of the lamps were out, and many others merely glowing. Dr. Hopkinson has apparently adopted the same method of assuming values for apparatus which he had not, perhaps, the time or inclination to check by actual tests. There are other points of a curious nature in the working of Messrs. Gaulard & Gibbs' apparatus to which we shall probably refer in a future issue. One of these, not of an electrical character, ought to be decided. It is this. The Siemens machine requires, say, an indicated horse-power of 25 to 30 to produce an electrical return of 16,710 watts. Does not the interposition of the secondary generators necessitate a still higher indicated horse-power to allow of the distribution of 15,018 watts? In other words, is there not a primary waste of actual horse-power over a direct method of distribution, in addition to the 20 per cent. or so, lost in the transformation?

INCANDESCENCE LAMPS FOR ASTRONOMICAL INSTRUMENTS.*

NOTE BY M. G. TOWNE, PRESENTED BY M. WOLF.

I HAVE succeeded in applying the incandescence electric lamp to the illumination of the lines of the network of my meridian circle and of my equatorial, as well as to the reading of the verniers of this instrument. Two lamps are sufficient for my observatory.

For my equatorial, one lamp is stationary. This lamp is placed in a copper tube, 0·08 metres long by about 0·04 metres diameter. At the orifice of the tube which faces the lens a glass is fixed, which prevents the heat from penetrating into the lens; at the other extremity is fixed a copper plug upon which two flexible conductors, which convey the current, bear with slight friction. This tube, which contains the entire system, is screwed upon the equatorial instrument opposite a moveable reflecting disc, forming a crown. This disc is pivoted and, by means of a button placed on the outside of the instrument, regulates the light up to complete obscurity of the field.

The other lamp, placed in a small special lantern, serves alternately for illuminating the lines of the meridian circle and for reading the verniers of this instrument. The conducting wires are placed at a certain height and arranged so as not to interfere with my movements during observations.

A commutator allows of instantaneously lighting either of these lamps. I regulate the light by variation of the intensity of the current by immersing, more or

* *Comptes Rendus.*

less deeply, the plates of the Trouvé battery (four elements are sufficient), whilst preserving the regulation by the reflecting diaphragm.

By means of this system of lighting, which allows of complete occultation of the lamp and of the special arrangement of the lantern, I can intercept every luminous ray, which is an invaluable point in astronomical observations.

VOLK'S AUTOMATIC REVERSING COMMUTATOR.

THE accompanying engraving reproduced from the *Engineer*, illustrates an apparatus devised by Mr. Magnus Volk, of Brighton, for sending a current in one direction for charging accumulators from a dynamo when driven in either direction, as from a railway

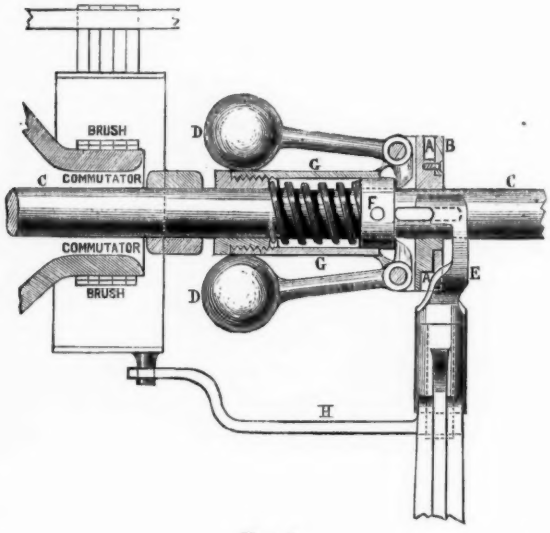


FIG. 1.

carriage axle, and at the same time altering the lead of the brushes proportionally to the speed of the machine, and connecting the accumulators only when the electromotive force of the machine is sufficient to charge

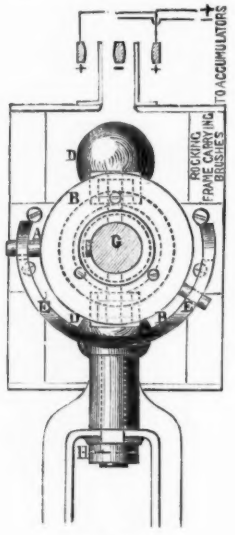


FIG. 2.

them. In the engravings similar letters denote similar parts. A is a loose ring or collar carrying two pins, A′ A″; B, part of sleeve connected with G; C, armature shaft; D, governors; E, rocking-fork, which actuates the frame by means of the arm, H; F, fixed collar on shaft, which acts on fulcrum for governor arms to shift along the shaft; G, sleeve carrying governor. The action is as follows:—The machine being at rest, keeps the circuit broken; when started the contact is not made until a predetermined speed is attained, this being fixed by adjusting the governor spring in the sleeve, G, the rising of the sleeve causing one of the pins, A′ or A″ to press against the forked lever, E, rotating it on its axis, and by means of the arm, H, rotating the brush frame. When the direction of rotation of the machine is reversed, the loose collar, A, revolves a short distance, and brings the other pin on A into contact with E, so that the rising of the sleeve, G, will rotate E in the opposite direction, and consequently reverse the inclination of the brush frame. It will thus be seen that as soon as the speed of the generator falls to a little above that at which the electromotive force is less than that of the secondary batteries being charged, the circuit is broken, and is not again completed until the speed of rotation in either direction is high enough to give an electromotive force greater than that of the battery.

THE REVERSAL OF HALL'S PHENOMENON.

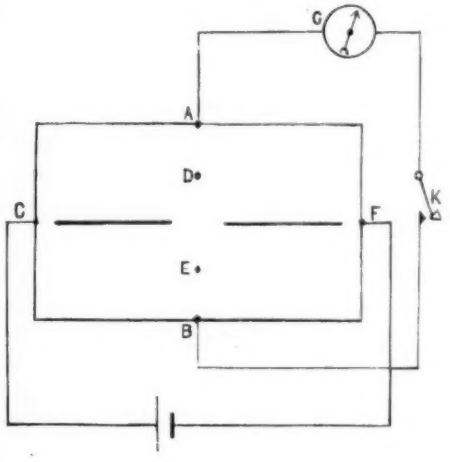
MR. SHELFORD BIDWELL, writing to *Nature* last week, says:—In a recent communication to the Physical Society, I mentioned among other things, that I had succeeded in reversing the direction of the Hall effect in iron. It was, however, found to be so exceedingly difficult to keep the two points where the galvanometer connections were made at the same potential, even for a few seconds, that the extent of the deflections due to the Hall effect could only be roughly guessed at, and the experiment was hardly a satisfactory one. I believe this inconvenience arose from the fact that the iron, being a strongly magnetic metal, was slightly displaced whenever the polarity of the electro-magnet was reversed, thus shifting the points of contact with the galvanometer wires. I have since repeated the experiment with gold, which turns out to be perfectly easy to work with, and altogether more suitable for the purpose. The following is an account of four experiments:—

Experiment 1.—A piece of nearly pure gold foil 5 cm. long, and 3·5 cm. broad, was cemented to a plate of glass, and the whole placed between the flat pole pieces of an electro-magnet. The middle points, A, B, (see figure) of the longer sides of the foil were connected to a galvanometer, G, and the middle points, C, F, of the shorter sides to a battery. A current was passed through the metal from left to right, and the electro-magnet excited so that a south pole was beneath the glass and a north pole above it. The galvanometer was immediately deflected, indicating a current flowing in the direction B, G, A. If either the polarity of the magnet or the direction of the current through the foil was reversed, the transverse current was also reversed and flowed in the direction A, G, B. This is the ordinary "Hall effect," and the direction of the transverse currents agrees with that mentioned by Mr. Hall for gold. The extent of the deflections varied from about 50 to 70 scale divisions on each side of zero. Similar but smaller deflections occurred when the galvanometer was connected with points nearer to the middle of the plate.

Experiment 2.—Two longitudinal slits, F, H, about ¼ mm. wide, were then cut along the middle of the foil, leaving a connection 4 mm. wide between the two halves of the sheet, and the former experiment was repeated. The following are the details; and to understand them it must be remembered that the galvanometer is affected by two causes besides the transverse current: (1) by the direct action of the electro-magnet upon the galvanometer needle, though 13 feet away from it; (2) by a small permanent current due to the fact that, however carefully ad-

justed, A and B are never (or hardly ever) at exactly the same potential.

The image of the galvanometer wire was brought as nearly as possible to zero of the scale before beginning the experiment, and the connections were made so that a current in the direction A, G, B, caused a deflection to the left (—), and a current in the direction B, G, A, caused a deflection to the right (+).



Upper pole of magnet north :—

Galvanometer key, K, raised, deflection + 25 divs.*
„ „ depressed, „ + 102 divs.†

Upper pole of magnet south :—

Galvanometer key raised, deflection — 24 divs.
„ „ depressed „ — 42 divs.

Net deflections due to current (subtracting effect of the magnet on the galvanometer needle) :—

Upper pole north (102 — 25 =) + 77 divs.
„ south (— 42 + 24 =) — 18 divs.

Sum of opposite deflections due to transverse current, (77 + 18 =) 95, or deflection on each side of zero = 47·5 divs.

The slits therefore had the effect of reducing the amount of the Hall deflections ; the direction was unaffected.

Experiment 3.—The galvanometer contacts were now moved from the edges to the points, D, E, about 5 mm. from the middle line, and the experiment was repeated with the following result :

Upper pole of magnet north :—

Key raised, deflection + 18 divs.
„ depressed „ + 165 divs.

Upper pole south :—

Key raised, deflection — 35 divs.
„ depressed „ + 180 divs.

Net deflections due to current :—

Upper pole north (165 — 18 =) + 147 divs.
„ south (180 + 35 =) + 215 divs.

Sum of deflections due to transverse current (215 — 147 =) 68.

Deflection on each side of zero = 34 divs.

Thus when the galvanometer contacts were near the middle of the plate, the deflections were almost as great as when the galvanometer was connected to the edges. *But they were in the opposite direction*, showing that the Hall effect was reversed.

Experiment 4.—A repetition of the last.

Upper pole north :—

Key raised, deflection + 28 divs.
„ depressed „ + 170 divs.

Upper pole south :—

Key raised, deflection — 24 divs.
„ depressed „ + 170 divs.

Net deflections due to current :—

Upper pole north (170 — 28 =) 132 divs.
„ south (170 + 24 =) 194 divs.

Sum of deflections due to transverse current, (194 — 132 =) 62.

Deflection on each side of zero = 31 divs.

These results, curious as they are, were of course not unexpected, the experiment having been in fact devised for the purpose of testing in an absolutely conclusive manner the sufficiency of the explanation of Hall's phenomenon by strains and Peltier effects which I have recently proposed.

Supposing the magnet and the battery to be so arranged that before the slits were made the points, A and D, were in stretched districts, and B and E in compressed districts of the metallic sheet, then the effect of cutting the slits will be practically to divide the plate into two independent plates, each of which undergoes strains similar to those originally existing in the whole. A and B, therefore will still be in regions which are respectively stretched and compressed, while on the other hand the region in which D is will now be compressed, and that in which E is will be stretched. Thus as regards the points, D and E, the result of making the slits is to reverse the strain, and in consequence, the Peltier effects and the galvanometer deflections. If Mr. Hall's own theory were correct, the existence of the slits should make no appreciable difference of any kind. That they should have the effect of *reversing* the action of the magnet upon the current is altogether inconceivable.

* Due solely to the action of the magnet upon the galvanometer needle.

† Due partly to the action of the magnet on the galvanometer needle, partly to the permanent current above referred to, and partly to the transverse current resulting from magnetisation.

UNDERGROUND WIRES.

AMERICAN experience in the employment of underground wires for telephony has been much the same as our own. Mr. Downs, the general manager of the New England Telephone Company, is reported to have made the following remarks on facts which came before his notice :—

"We have two underground lines at work now in Boston. One runs from this office, 40, Pearl Street ; one to State Street, and the other to the corner of Franklin and Washington streets. We picked out five of the best cables invented, and put them in pipes. There are five cables and seventy wires. All show induction of wire with wire, and retardation from influences in the earth. The results prove that with any of the present systems a line cannot be operated for any great distance. The influences I have mentioned would prevent the satisfactory working of a line as far as from here to Dover Street, and would wholly kill a line to a town at any distance from Boston. We have been experimenting for a year and a half, and so far have had no satisfactory results, though wherever we have heard of anything on the subject we have investigated it. If the time comes when it can be demonstrated that any underground system is practicable, the companies will be only too glad to take advantage of it. They want to do so now, but they do not know how it can be done."

Mr. T. D. Lockwood, the electrician to the Bell Telephone Company, speaks in much the same strain. From an article in the New York *Electrical Review*, we can briefly sum up this gentleman's experience.

Mr. Lockwood says : "We have got over the difficulty of defective insulation in a great measure, but still have to contend with induction and retardation.

"It is true that from 800 to 1,200 patents for systems claiming to overcome the difficulty have been granted ;

but it is also true that the inventors do not know what the trouble is. They work with the idea of securing insulation, but that is the least of the difficulties."

In Paris all wires are underground, and if we had such underground facilities as exists there we should not hesitate in the matter. In London only telegraph wires are underground, and they lead through pipes to the central office. The telephone wires are above ground, and cannot be worked underneath. A telegraph line can be worked where a telephone line cannot be, because the telephone is so highly sensitive.

"In 1880 the American Bell Telephone Company commenced to see that with their wires underground, although the first expense would be large, the cost of maintenance would be small, provided durability were insured and the system would work. In consequence of an idea of my own, five miles of cable, with about twenty wires, were laid on the Providence railroad between Attleboro and West Mansfield. The $20,000 which it cost lies buried there to-day. Such of the cable as has not been stolen lies there useless. The experiment was a failure because of the induction between wire and wire and retardation by earth currents. The effect of retardation is to run one sound into another. With 5,000 inflections of the human voice in a second, you can judge of the effect on a telephone. On 12 miles of submarine wire laid at Block Island, articulation was completely choked. Two miles is the limit for work on underground telephone wires, and then they do not work as well as when overhead."

THE ELECTRICAL TRANSMISSION AND DISTRIBUTION OF ENERGY.*

By MARCEL DEPREZ.

* Translated from *La Lumière Electrique.*

(*Continued from page* 267.)

Corollary I.—When the volume and the form of a conductive system are invariable, a given static effort costs always the same expenditure of energy for its production.

We have just seen that we may symbolically represent the resultants of the elementary efforts under the form $F = \frac{I^2}{a^2} K^4$.

If R is the resistance of the conductive system, E the inverse electromotive force developed by the displacement of the moveable part, l the length of the wire, V its volume, and c its conductivity

$$I = \frac{E}{R}, \quad \text{or} \quad R = \frac{l}{a\,c} = \frac{V}{a^2 c}$$

according to our symbolical notation, $V = K^3$, therefore $R = \frac{K^3}{a^2 c}$

consequently:

$$I = \frac{E\,a^2\,c}{K^3} \quad F = \frac{E^2\,a^4\,c^2}{K^6\,a^2} \times K^4 = \frac{E^2\,a^2\,c^2}{K^2}.$$

On the other hand, the total quantity of energy, Q, received by the conductive system is equal to $\frac{E^2}{R}$

$$Q = \frac{E^2}{R} \cdot \frac{E^2\,a^2\,c^2}{K^3}$$

and the ratio $\frac{F}{Q} = K \times c$.

If the volume and the form are invariable, K is invariable, which proves that under these conditions in order to produce an effect, F, it is always necessary to expend the same quantity of energy, Q. We see, also, that the cost of the static effort is inversely proportional to the conductivity of the wire employed in the apparatus. The greater it is, the less energy it costs to produce one and the same effort.

Corollary II.—When all the dimensions of a conductive system are increased in the proportion, K, one and the same effort, F, is produced with an expenditure of energy K times smaller.

This corollary results directly from the foregoing formula

$$\frac{F}{Q} = K \times c.$$

From what has been said, we see how greatly advantageous are large dynamo machines. Not only are they more powerful per unit of mass, but they are also more economical.

It was partly in order to arrive at this conclusion that I established the theorem of similitudes. I have verified it experimentally.

I think it useful to furnish some details concerning these experiments.

I adopted for the conductive system a form of electro-dynamometer already indicated in principle by M. Mascart.

The central bobbin, B, is moveable at the end of the beam of a balance. A scale-pan, placed at the other end, enables us to counterpoise this bobbin by means of weights and then to measure the static effort developed in it when a current traverses the whole system.

The entrance and exit wires plunge into cups of mercury, so that electric communications may be established without altering the moveability of the apparatus.

The bobbins A and C are fixed.

The three bobbins are placed in a direct circuit and the direction of the current which traverses them is such in each of them that B is repelled by A and attracted by C.

To verify the theorem of similitudes it is necessary to have a second electro-dynamometer like the first. I chose one of double dimensions, so that when there is produced on the first a force of 1 k., there is developed on the second a force of 16 k.

The two apparatus placed in the direct circuit of a continuous current dynamo have given the following results for a current of 11 ampères:

	kilo.
Static force in the small apparatus	0·355
„ „ large „	5·600

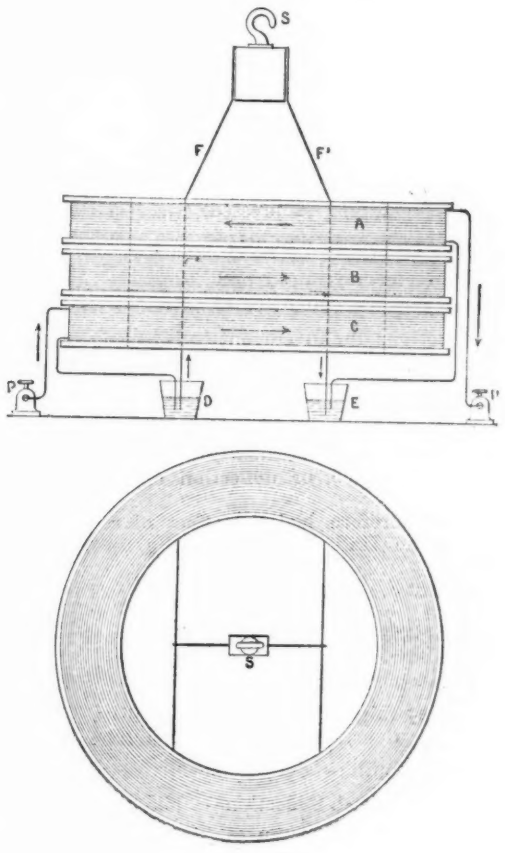


FIG. 15.

On multiplying by 16 the first static force, we get 5·680 kilos., differing only by $\frac{1}{50}$ from the amount found by direct measurement in the second.

The theorem of similitudes is evidently no longer applicable when we make use of alternating currents.

I have in this case examined experimentally how the effort varies with the dimensions of the apparatus.

I have found that the exponent of K = 3·66.

$$F' = \underset{\times}{K}^{3{\cdot}66} F.$$

The theorem is also not applicable when the bobbins have a core of soft iron.

In this case I have found experimentally the value 3·76 for the exponent of K.

$$F' = \underset{\times}{K}^{3{\cdot}76} F.$$

But this exponent varies much when we approach the saturation point of the soft iron in the small apparatus.

We may draw from this study the important conclusion that the future belongs to large dynamo machines. Weight for weight they are not merely more powerful, but more economical than the small ones.

We now know in what direction the existing types must be modified, and what advantage may be derived from constructing more powerful machines.

There remain a great number of other questions to solve. In the first place to find a simple method of appreciating machines, representing their actions so as to afford a method of comparison in what may be called an industrial form.

The formulæ which show the absolute work, and the yield of an electric motor as a function of the intensity of the current which traverses it, and of the inverse electromotive force which it developes have the defect of not showing in a sufficiently explicit manner the part played by the different elements which have an influence on the working of the motor.

They contain, besides, symbols (electromotive force, intensity of current, resistance), the exact meaning of which is still obscure to many persons more versed in the study of mechanics than in that of electricity.

Hence they are received, not without mistrust, by a section of the public, which should feel the greatest interest in comprehending them, by reason of the daily increasing importance of the electric transmission of work.

These considerations have led me to attempt to eliminate from the formulæ relating to electric motors the electric quantities which figure therein, and to substitute for them expressions purely mechanical. I have succeeded by making use of a new element, which I introduced about two years ago, into the study of electric motors, and to which I gave the name "cost of static force."

I will explain the origin and the meaning of this term :—

When we direct a current into an electric motor, the fixed parts (inductors) and the moveable part (the ring) become the seat of reciprocal actions, which, in consequence of the arrangement of the apparatus, are reduced to a couple, which may be measured by attaching a suitable weight to a dynamometric break acting upon the ring. This couple varies with the intensity of the current, but experiment shows that it is constant as long as the current itself is constant, whatever may be the angular velocity of the ring. I define this couple by the weight which must be applied to one extremity of one arm of a lever of 0·159 metre to counterpoise it.

If we keep the ring in a state of rest, by applying to it a couple equal and opposite to that which developes the current, the useful work is nil, and yet there is an expenditure of energy in the form of the heat produced by the passage of the current.

This fact constitutes an essential difference between the electric motor and steam motors, in which the simple development of a pressure, not accompanied by a movement of the piston, requires an expenditure of energy quite insignificant, and without definite relation to the intensity of the pressure.

In the electric motor, on the other hand, I have shown that in order to create a couple of given intensity it is necessary to expend a certain quantity of energy which appears in the form of heat, and which, as expressed in kilogrammetres per second, is completely independent of the state of rest or motion of the ring as well as of the diameter of the wire coiled on the inductors and on the ring, and consequently on its resistance, provided that the outward form and weight of this wire (disregarding the non-conducting material with which it is covered) remain invariable.

It is expressed in kilogrammetres per second by $\frac{r\ I^2}{g}$, r being the resistance of the motor expressed in ohms, I the intensity of the current expressed in ampères, and g the acceleration due to the weight.

The quantity of energy developed in the entire circuit $= R\ I^2$, R denoting the total resistance of the circuit, comprising the generating and recipient machines and the exterior wire.

But, under the conditions explained above, when the current developed by the passage of the couple has a determined value, the quantity of energy $\frac{r\ I^2}{g}$ developed per second in the form of heat by the same current is perfectly fixed, whatever may be the diameter of the wire coiled upon the inductors and upon the ring.

We have then $\frac{r\ I^2}{g} = \phi\ (F)$, F being (in kilos.) the force which must be applied to the end of the lever-arm of 0·159 metre to counterpoise the couple produced by the current. This function, $\phi\ (F)$ varies with the arrangement and the absolute size of the motors, and can be generally determined only by experience, but (I repeat it, because of the great importance of this fact) when once determined for any given type of motor, it is independent of the diameter of the wires which may be coiled on this motor, provided that the form and the weight of these wires remain invariable.

From the expression $\frac{r\ I^2}{g} = \phi\ (F)$, we deduce $\frac{I^2}{g} = \frac{\phi\ (F)}{r}$ developed in the entire circuit $\frac{R}{r}\ \phi\ (F)$.

If to this quantity of heat we add the work developed in a unit of time by the recipient motor, we obtain the total energy developed per second in the entire circuit, *i.e.*, the work expended by the generating machine, or by the source of electricity.

This being established, let us call F_1 and F the couples developed respectively in the generating machine and in the receiver by the passage of the current, and by v_1, v the angular velocities of these machines ; the work absorbed by the generating machine in a unit of time will $= F_1\ v_1$, while the energy developed in the entire circuit will $= \frac{R}{r}\ \phi\ (F) + F\ v$. We have then the equation

$$(1) \qquad F_1\ v_1 = F\ v + \frac{R}{r}\ \phi\ (F)$$

The mechanical work recovered being $= F\ v$, the economical return, K, has the expression—

$$(2) \qquad K = \frac{F\ v}{F_1\ v_1} = \frac{F\ v}{F\ v + \frac{R}{r}\ \phi\ (F)} = \frac{v}{v + \frac{R}{r} \cdot \frac{\phi\ (F)}{F}}$$

From the equation (1) we infer $F_1\ v_1 - F\ v = \frac{R}{r}\ \phi\ (F)$.

This equality signifies that, being given the couple developed by the recipient (in practical language the load of the brake), the difference of the work developed per second by the generator and the recipient (*i. e.*, the work lost) is constant, provided that the ratio of the total resistance of the circuit to the resistance of the recipient remains constant. We see that this lost work does not depend on the absolute values of R and r, but solely on their mutual relation, and it is the same with the economic return, K.

This is a very important result which is here, for the first time, put in an explicit form. As far as the economic yield, we see that it depends merely on the three following quantities:

1. v, the velocity of the recipient. The yield approaches unity when v increases indefinitely.

2. $\frac{R}{r}$, the ratio of the total resistance of the circuit to the resistance of the recipient. The value of this ratio is always > 2, if the two machines are identical.

3. $\frac{\phi\ (F)}{F}$, *i.e.*, the quotient of the calorific work developed in the recipient by the mechanical couple resulting from the passage of the current. To this quotient I have given the name of "*cost of the statical effort.*" This quotient is of very great importance, for the economic yield at equal velocities is nearer unity the nearer $\frac{\phi\ (F)}{F}$ approaches zero.

But whilst we may assign to v and to $\frac{R}{r}$ arbitrary values independent of the form and the arrangement of the motor, the value of $\frac{\phi\ (F)}{F}$ is, on the contrary, absolutely independent of the diameter of the wires coiled upon the inductors and the induced. But it varies with the relative dimensions of the inductors and of the ring, and with the manner of coiling the wires ; in a word, with the arrangement of the masses of iron and copper which make up the motor. If there is a given weight of matter (copper and iron), there exists a mode of arrangement for which $\frac{\phi\ (F)}{F}$ is a minimum, the value of F being given. Experience alone enables us to find approximately what this arrangement must be.

If we connect, n, identical motors acting on the same axle and traversed by the same current, the couple becomes $n\ F$, and the expenditure of energy necessary to produce this couple $\frac{n\ r\ I^2}{g}$; the quotient of this expression by $n\ F$, *i.e.*, $\frac{\phi\ (F)}{F}$ would then have the same value for this collection of motors as for a single motor. If, on the contrary, we take a single motor, geometrically similar to one of these motors, weighing n times as much and, consequently, larger in the ratio of $\sqrt[3]{n}$ to unity, the quotient $\frac{\phi\ (F)}{F}$ will decrease in a proportion greater than that of the homologous dimensions, as I have shown above.

A single motor is, therefore, superior to a totality of motors weighing, collectively, as much as it does.

These notions having been established, it is interesting to apply them to the experimental study of the machines. I give here some instances of the researches which have been made in this direction.

There are two methods of measuring the couple which tends to cause the ring to revolve under the action of a given current : by theoretical deductions or by experimental procedures.

I will begin by showing how we may deduce from the characteristic the value of the couple corresponding to each intensity.

Let F be the effort (expressed in kilogrammetres) which must be applied at a distance from the axle equal to $\frac{1}{2}\frac{m}{\pi} = 0{\cdot}159$ metre to overcome the resisting effort developed by the current when the machine serves as a generator.

V, the velocity in metres per second of this point, situate at 0·159 metre from the axle.

E, the electromotive force developed in volts, and I, the intensity of the current in ampères.

The total quantity af energy developed per second is, in kilogrammetres $\frac{E\,I}{g}$. It is, in a perfect machine, strictly equal to the external work applied to the ring, or F V. We have, therefore:

$$\frac{E\,I}{g} = F\,V; \quad \text{whence } F = \frac{E\,I}{g\,V}.$$

But if we have the characteristic of the machine for a speed equal to 1 metre per second (and we may always construct it if we have the characteristic corresponding to any speed whatever in virtue of the proportionality of the electromotive forces to the velocities at equal intensities), and if we call e the electromotive force corresponding to the intensity, I, for this velocity of one metre we have

$$E = e\,V, \text{ whence } F = \frac{e\,I}{g}.$$

This equation gives immediately F as a function of I if we know the equation of the characteristic. This equation is not known, but we have seen that the first portion of the characteristic may, in general, be considered as an inclined straight line, the equation of which is of the form $e = m\,I$, m being the coefficient of inclination of this straight line. Hence $F = \frac{m\,I^2}{g}$.

This equation shows that for low intensities, or, to speak more correctly, for low densities of current (we shall subsequently see why), the couple is proportional to the square of the intensity of the current. This will be strictly true in a machine composed of circuits into which no magnetic metal enters (like the dynamometers), whatever may be the intensity of the current.

In the portion of the characteristic which is parallel to the axis of x, e is constant, and the couple becomes in consequence simply proportional to the intensity of the current.

If we, therefore, construct the curve of the static efforts, taking as abscissæ the intensities of the current, and for ordinates the corresponding couples, we see that in the neighbourhood of its origin this curve approaches a parabola, whilst for great intensities of the current it is reduced to a straight line.

Let us now see how we may construct the curve of the static efforts experimentally. For this we must have a procedure, which permits us to measure, with precision, the couple developed on the ring by electric action alone, *i.e.*, eliminating the friction of the supports, the brushes, the resistance of the air, and the vibrations. Transmission-dynamometers cannot be used, because they only enable us to measure the total effort, and besides, they do not present sufficient precision.

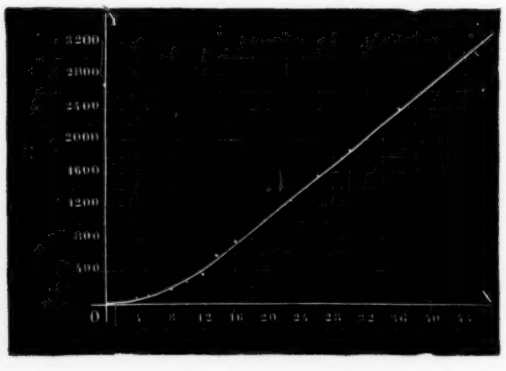
Curve No. 29.

CHARACTERISTIC OF GRAMME MACHINE (MODEL A FOR GALVANOPLASTICS).

Curve of the static efforts.

I	F	I	F	OBSERVATIONS.
	Gr.		Gr.	
1	20	24	1,410	The brushes are in the median plane.
4	55	26	1,575	
6	115	28	1,725	
8	185	30	1,875	
10	290	32	2,025	
12	400	34	2,210	
14	575	36	2,375	
16	730	38	2,530	
18	890	40	2,680	
20	1,060	42	2,851	
22	1,220	44	3,025	

Diagram of Curve 29.



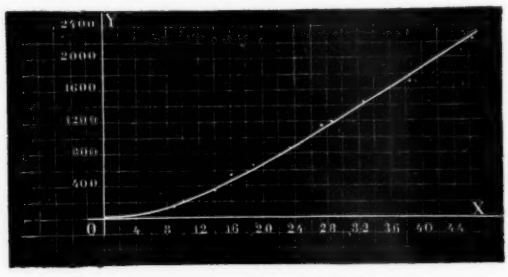
Curve No. 30.

CHARACTERISTIC OF THE GRAMME MACHINE (MODEL A, FOR GALVANOPLASTICS).

Curve of static efforts.

I	F	I	F	OBSERVATIONS.
	Gr.		Gr.	
2	10	26	1,000	The brushes are at an angle of 45° to the median plane, in advance of the rotation.
4	40	28	1,120	
6	75	30	1,240	
8	130	32	1,360	
10	190	34	1,470	
12	270	36	1,600	
14	350	38	1,730	
16	440	40	1,860	
18	570	42	1,970	
20	665	44	2,100	
22	770	46	2,220	
24	880			

Diagram of Curve 30.

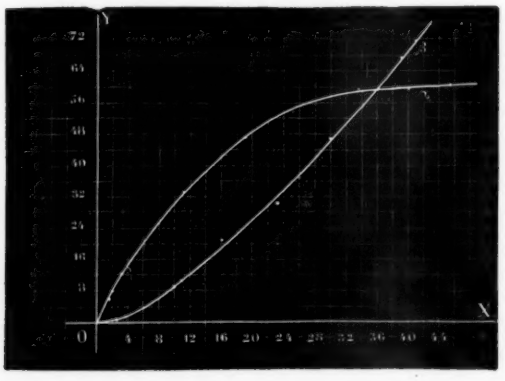


Curve No. 32.

CHARACTERISTIC OF GRAMME MACHINE, MODEL A (strengthened). Velocity of 1,100 Revolutions.

I	E	$\frac{E\,I}{g} \times \frac{60}{n}$	F kilos.	Relative differences.	OBSERVATIONS.
		gr.	gr.		
2	8	86·4	0·120	28 %	Total resistance: R = 0·304.
4	14·75	312·5	0·400	21·8	
6	20	650	0·800	18·7	
8	26	1,120	1·300	13·85	The inductors are mounted on knife edges, and can revolve on an axis in the prolongation of that of the ring. The ring is mounted upon two independent supports. The static effort developed is measured on the inductors (Curve β). The characteristic for the speed given to the ring is shown in Curve α.
10	30·5	1,650	2·000	17·50	
12	35	2,270	2·700	15·90	
14	38·75	2,830	3·400	16·75	
16	42·50	3,175	4·200	24·40	
18	42·76	4,450	5·000	11	
20	45·75	5,200	5·800	10·35	
22	51	6,050	6·800	11	
24	53·25	6,900	7·600	9·20	
26	55	7,700	8·300	7·23	
28	56·25	8,500	9·200	7·60	
30	57·25	9,300	10·000	7	
32	58·25	10,200	10·800	5·55	
34	59	10,800	11·800	8·50	
36	59·25	11,600	12·600	8·70	
38	59·50	12,200	13·300	8·25	
40	59·75	12,900	14·200	9·15	
42	60	13,600	15·100	9·95	
44	60·25	143,00			
46	60·50	15,000			

Diagram of Curve 32.



I have solved this question by applying a new method of measurement which I devised some years ago. The supports and the brushes of a Gramme machine (of the type A, strengthened) are removed from the inductors and fixed upon a frame, whilst the inductors together are mounted upon knife edges, situate in the prolongation of the axis of rotation of the ring.

To the inductors is attached a lever of 0·318 metre in length, carrying a scale-pan for receiving weights. A long needle, playing before a scale, enables us always to bring back this kind of balance to the same condition of equilibrium by adding or removing weights. Fig. 32 shows the results obtained.

The curve, α, is the characteristic, and β is the curve of static forces obtained by direct weighing, whilst the ring rotates at the velocity of 1,110 turns per minute.

Fig. 29 shows the curve of the static forces measured in the same manner when the machine is at rest, and a current derived from a foreign source is directed into it. We remark that in this latter case the efforts approach closely to the forces calculated by the formula $\frac{E\,I}{g\,v}$ or, what amounts to the same thing, $\frac{E\,I}{g} \times \frac{60}{n}$, n being the number of revolutions per second effected by the ring when the characteristic is set up. On inspecting the figure 32, we perceive that the force, F, as measured, is always greater than the theoretic force $\frac{E\,I}{g} \times \frac{60}{n}$ by 7 to 10 per cent., whilst the difference between the two forces almost vanishes when the ring is at rest. This must be so, since, when the ring is in motion, it is the seat of parasitic electric phenomena, depending on the fact that the current generated is not perfectly continuous in virtue of the very construction of the ring. This agreement between the results of calculation, and those of experiment, is the best verification of the body of fundamental theorems relating to the transmission of force, for, if only one of them was inaccurate, this verification could not exist.

Here is a further verification. We take a small galvanoplastic machine and remove the knee-pieces, leaving the ring in the place which it occupies habitually in the magnetic field, and fitting it with knife-edges which leave it an absolute freedom of movement. One arm of a lever, in perfect equilibrium, and of 0·159 metre in length, carries a scale-pan in which are placed weights, to counterpoise the action of the current, and a long needle serves to bring back the system to the same position on weighing. The current is conveyed to the ring by means of wires soldered to the blades of the collector and dipping into cups filled with mercury. Three cases have been studied: 1, when the line of entrance and exit of the current into the ring forms with the axes of the magnetic field an angle of 90°; 2, when it makes an angle of 45° reckoned in the direction of the couple which attracts the ring with the axis of the field; 3, when it makes with the axis of the magnetic field an angle of − 45°, reckoned in the same direction. This last case corresponds to that where the machine serves as a generator, since then the couple is resistant, and the brushes, as is known, are levelled 45° behind the symmetrical position. We see, on examining fig. 30, that under these conditions the agreement between calculation and experiment is as perfect as possible. The same verification cannot be effected for the two other cases because the corresponding adjustments of the brushes would occasion considerable sparks, which would quickly injure the brushes and the collector. We may, however, observe, that modifying the brushes so as as to approach a symmetrical position, the electromotive force diminishes. Therefore, in virtue of the equation $\frac{E\,I}{g} \times \frac{60}{n} = F$, the couple must diminish also.

This is what, in reality, takes place. I have given above the explanation of the influence of the adjustment of the brushes on the electromotive force.

I attach great importance to the experimental verification of the formula which shows the static force, since it enables us to study the design of an electric-motor as we study that of a steam engine.

I will here conclude the details of the experimental studies which I have made on dynamo-electric machines. The complete exposition of these researches would require almost a volume.

To be complete it would have to include the investigations made on the construction and the regulation of the machines, the description of the various models which I have been led to construct, and the various appliances which I have had to combine in order to fulfil the conditions required in practice. Some of these descriptions would be too lengthy, and others would be out of place in this journal.

I must confine myself to the brief indications which I am about to give, which seems to me suitable to give an idea of the tendency of these researches, and which will suffice to bring out the principal features.

Still, before entirely quitting this subject, it seems to me useful to give some details on a motor of a peculiar kind which I have constructed, in which electric action is carried to a high degree of power.

Its principal organ is a divided solenoid, whieh I have also applied to an electric motor which I laid before the Société de Physique in July, 1880.

Suppose that we place upon each other 100 flat bobbins of a centimetre in thickness, so as to form a single solenoid of a metre in height, and that the entrance and exit wires of each are connected to the wires of the neighbouring bobbins exactly in the same manner as they are in the consecutive sections of the ring of a dynamo machine. Let us complete the resemblance by causing each junction of the wire of one of the bobbins to the wire of its neighbour to abut on a metal plate cemented to an insulating bar containing as many plates as there are bobbins, plus one. Along this kind of collector, which may be either rectilinear or coiled on a cylinder, let us move two brushes fixed to an insulating piece which may be worked by hand. If we place the two brushes at such a distance that the number of blades of the collector comprised between them may be, *e.g.*, 10, and if, after having connected them, we displace them in any manner, the current entering at one of these brushes and taking its exit at the other, will always traverse 10 bobbins. Everything will then go on as if, in place of moving the brushes, we were to move the solenoid formed by the connection of the 10 bobbins.

This being arranged and the bobbins being in any position, let us direct a current into the apparatus and place in it a cylinder of soft iron. According to a well-known experiment, this cylinder will remain suspended in the interior of the solenoid formed by the connection of the 10 bobbins, and its centre will place itself at a distance from that of the solenoid so much the greater as the

FIG. 25.

current is less intense. It will even drop entirely if the current has not an intensity greater than a certain minimum value, which depends on many conditions into which we need not enter at present. We will suppose that the current is so intense that the distance of the two centres from each other is much less than what would occasion the fall of the cylinder. When this condition is fulfilled, we find that the iron cylinder is in equilibrium, and that if we wish to remove it we must apply a force increasing with the removal, just as if it was suspended to a spring.

Hence it follows that if we displace the brushes by a magnitude equal to the thickness of one of the blades of the collector, the active solenoid undergoes the same displacement, and its centre will remove from that of the iron cylinder, and the attraction excited on the latter will increase. It cannot return to its original value, and the equilibrium can only be re-established if the cylinder experiences a displacement identical with that of the solenoid. But as this latter depends on the movement impressed upon the brushes collectively, we see that the cylinder will accurately reproduce the motion given to the brushes by the hand of the operator.

This apparatus is, therefore, a true electric servo-motor, in

which the current is never either interrupted or modified in magnitude or direction, no more than the magnetisation developed in the cylinder of soft iron.

Everything goes on as if the cylinder of iron was suspended in a solenoid of 10 centimetres in length, which was caused to ascend or descend, with this difference, that the weight of the cylinder exerts no action upon the hand of the operator.

These explanations being understood, little remains to be said to render the action of the hammer completely intelligible.

The elementary sections forming the electric cylinder, A B, of the hammer are 80 in number, the entire length being about 1 metre. Their entrance and exit wires abut on a circular collector, F G. The brushes are replaced by two plates, C E, C D, fixed to the double crank, H C I, moveable on the fixed centre, C; they can form with each other any angle, so that we may give the active solenoid the most convenient length by approximations. When this angle has been determined, the angle, E C D, is fixed permanently by means of a set-screw, and the apparatus is worked by giving the double crank, H C I, a circular alternating movement.

The iron cylinder weighs 23 kilos, but when the current has the intensity of 43 ampères, and traverses 15 sections, the force developed may reach 70 kilos, or three times the weight of the hammer. This latter obeys the movements of the operator's hand with absolute docility. By carrying the current to very great intensities I have raised the force to the value of 180 kilos. I must remark that similar powers have never been produced before. It is said that in certain old experiments Page reached 100 kilos; it is easy to see that this is impossible. We know that Page operated with 100 Grove's elements. But the quantity of work which one such element can furnish does not exceed 1·3 kilo. Page had, therefore, at his disposal 130 kilogrammetres—an energy absolutely inadequate for obtaining the efforts which he is said to have realised.

It seemed to me useful to call attention to this apparatus, because special investigations have shown me that the static force may be obtained by its means with a less outlay of energy than by the dynamo machines. Serious mechanical difficulties would oppose the construction of practical machines based on this principle, but their value should not be overlooked.

ON A NEW STANDARD OF ILLUMINATION AND THE MEASUREMENT OF LIGHT.*

By WILLIAM HENRY PREECE, F.R.S.

1. The present position of photometry as practically applied to electric lighting is by no means in a satisfactory condition. Mathematical accuracy in the measurement of the intensity of the light emitted by a given source is unobtainable owing to the numerous disturbing influences of quality and quantity which render impossible any graduated scale of light. An *absolute* standard of light has not yet been obtained. I have long felt that to meet the case of electric light illumination we must not depend upon any direct comparison between the light emitted by the source to be measured and any given recognised standard of light; but that we should rather make our standard of comparison an area illuminated to a given intensity whatever be the source of light. We do not want to know so much the intensity of the light emitted by a lamp, as the intensity of illumination of the surface of the book we are reading, or of the paper on which we are writing, or of the walls upon which we hang our pictures, or of the surface of the streets and of the pavements upon which the busy traffic of cities circulates. Illumination of this character depends not on one source only, but on many sources of light distributed in innumerable ways. Hence, I propose to measure the illumination of surfaces quite independent of the sources of light by which they are illuminated. The difficulties in comparing the illumination of spaces have hitherto been insurmountable, but now, thanks to the beautiful little glow lamps introduced by Mr. Swan, these difficulties have disappeared.

The standard I propose is the space illuminated by one British standard candle at 12·7 inches distance, which is the same as the illumination given by one French standard "bec" on the same space at 1 metre distance.

2. The principle of measurement which guides us in nearly all the methods at present in practical use is to compare two surfaces equally illuminated to the same intensity by lights placed at different distances, and to compare them by the law of inverse squares determined by Kepler. This law, however, assumes a clear space through which the light is transmitted, and the emission of this light from a point. Distance therefore becames essential, and the error introduced by large flames or by the diffusion of light becomes difficult to eliminate; indeed, by the present system it is well-nigh impossible to measure satisfactorily the light-giving power of several lamps distributed over a room or large area. Moreover, the principle ignores the presence of different colours, and it involves the necessity, with electric arc lamps, of taking measurements at different angles.

Up to the present time, the simplest and perhaps the most favourite mode of measurement is Rumford's plan of contrasting shadows, but Bouguer's method of comparing equally illuminated surfaces, as carried out by Ritchie and Bunsen, is also in great favour.

3. All these plans, however, are dependent upon the establishment of a uniform standard of light. Although in England, Parliament has legalised the standard candle, it has been found so inconvenient in practice, owing to its want of uniformity, that Mr. Vernon Harcourt has felt it advisable to replace the standard spermaceti candle with a flame resulting from the combustion of pentane. In France, again, the standard is the Carcel bec, burning at the rate of 0·0042 kilo. of pure colza oil per hour, with a flame of 40 millims. while Draper (1847), Zöllner (1859), and Schwendler (1879), proposed a given length or surface of platinum raised to incandescence by a current of electricity as a useful standard. At the Congress held in Paris last year it was suggested that a convenient standard would be the light emitted by a square centimetre of incandescent platinum maintained at its fusing point, but up to the present moment no one seems to have devised what really may be called an absolute standard of white light. The question is now being considered by a committee of the British Association. If it were possible to find a convenient, simple, fixed, and uniform material which, having a resistance of one ohm, could be raised to incandescence by one ampère flowing through it, we should have a convenient standard, but this has not yet been obtained.

As I have said, the standard of comparison I propose is a uniformly illuminated surface. I thought at one time that we might have made use of sunlight for this purpose, but I find that sunlight and moonlight are even more variable than the light produced by artificial means, and, after innumerable trials, I have come to the conclusion that the standard which I have proposed is one very easily obtained, and though not absolutely fixed, can be made as nearly uniform and reproducible as any standard hitherto suggested. It is true that it is of a secondary character, and dependent primarily upon a recognised standard source of light; but this primary standard remains in the laboratory, while the measurement can be made in the streets, on board ship, or wherever the surface of illumination may be.

4. Having thus fixed upon a standard of illumination it became desirable to devise an instrument that would enable us to compare areas differently illuminated.

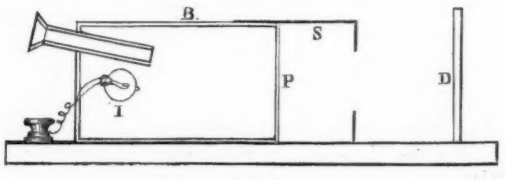


FIG. 1.

For this purpose I make use of a small Swan glow lamp giving 2½ candle-power with the current produced by 5 volts. The construction of the photometer is shown by figs. 1 and 2. The lamp, L, is fixed inside

* Read before the Royal Society, June 21, 1883.

a cylinder or box, B, blackened in the interior, over the end of which is stretched a diaphragm of drawing paper, P; the latter has a round grease spot in the centre about the size of a shilling, as in Bunsen's photometer. At about 12 inches distant from the end of the tube a screen, D, of white drawing paper is fixed. The diaphragm, P, is so screened by a sliding cover

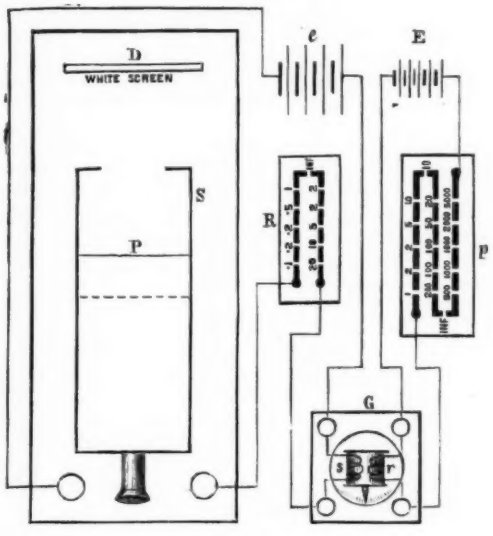


FIG. 2.

that no light falls upon it but that which is reflected from the drawing paper, D. At the end of the tube where the glow lamp, L, is set is an eye-piece, through which the illuminated surface of the diaphragm at the end of the tube can be observed. Beneath the base of the instrument is fixed a secondary battery (*e*, fig. 2) which enables us to transmit a current of any desired strength through the glow lamp, L. A rheostat, R, is fixed in circuit with this battery, and enables the current to be adjusted at will; the strength of the latter is read on a graduated electrodynamometer, or upon a galvanometer.

For laboratory purposes a more accurate mode of measuring the intensity of the current is the following:*—

G is a galvanometer wound with two coils, one (*s*) consisting of a short length of thick wire, and the other (*r*) of a long length of thin wire. In circuit with the latter coil is a resistance, *p*, and a standard battery, E.

The relative deflective values of the coils, *s* and *r*, for similar currents being as 1 to *n*, then when balance is obtained on the galvanometer, the current, C, flowing through the coil, *s*, will be—

$$C = \frac{n E}{r + p},$$

r being the resistance of the galvanometer coil and battery, and E the E.M.F. of the battery, E.

Thus if the relative deflective values of the coils, *s* and *r*, are as 1 to 473, that is, if $n = 473$, then if E consists, say of a 5-cell Daniell battery, and the resistance, *r*, of the galvanometer coil and battery be 800 ohms, the current, C, when balance is obtained by adjustment of *p*, will be—

$$C = \frac{473 \times 5 \times 1{\cdot}07}{800 + p} = \frac{2530}{800 + p}$$

Practically with this arrangement a change of $\frac{1}{1000}$th of an ampère in the current through the coil, *s*, can easily be detected, and currents can be read to three places of decimals.

To work the instrument it is only necessary to place the screen (D) in the place whose illumination is to be determined, and then by means of the rheostat, R, to lower or increase the current passing through the lamp until the grease spot, when viewed through the eye-piece, becomes invisible, then the light reflected on the diaphragm and transmitted through the grease spot by the distant surface of drawing paper will be equal to the light thrown upon the opposite side of the diaphragm by the glow lamp. The current producing the light thus becomes a measure of the illumination of the screen.

The following measurements were made to determine the current that gave various degrees of illumination—the source of light being a standard candle.

Distance of source of light from illuminated surface.	Equivalent degree of illumination.	Current through lamp required to produce balance of illuminations. (C.)	$C^6 \times 15{\cdot}994$.
Feet.		Ampères.	
·50	64·000	1·260	64·000
·75	28·445	1·100	28·335
1·00	16·000	·959	12·442
2·00	4·000	·790	3·888
3·00	1·778	·690	1·726
4·00	1·000	·651	1·217

From these experiments it appears that the illuminating power of the glow lamp increases in the ratio of the sixth power of the current. Hence it is only necessary to read the current that gives the necessary equivalent to determine the degree of illumination.

The current in ampères thus gives, for the particular glow lamp employed, a number whose sixth power expresses the amount of illumination measured.

The apparatus works with ease and regularity, but it has this difficulty—that it is dependent upon the constancy of the lamp, a point not yet absolutely attained. The glass envelope of the lamp becomes deadened by use; the carbon fibre of the lamp gradually becomes deteriorated; and the vacuum sometimes fails. These operations, however, are very slow ones, and it is only necessary occasionally to compare either the light given by unit current with that in the laboratory thrown upon a surface by a standard candle, or by one of Mr. Vernon Harcourt's pentane lamps.

It is, however, certain from numerous experiments and practical trials that the light produced by the incandescence of a given carbon filament due to the passage of a given current is more easily reproduced from one time to another, and is more uniform than probably any other artificial standard of light.

THE LATE ELECTRICAL EXHIBITION AT THE CRYSTAL PALACE.

LAST week we presented to our readers a tabulated series of tests, taken from Prof. W. G. Adams' inaugural address to the Society of Telegraph Engineers and Electricians, on the dynamo-electric machines, which figured in the late Electrical Exhibition held at the Crystal Palace during 1881–1882. As it is well that our readers should know the methods of measurement adopted for arriving at the figures given in the table, we shall reproduce that portion of the Professor's address which deals directly with the tests. We will commence with the lecturer's remarks on the subject of motive power. He says:—

In every form of engine which is practically useful for the conversion of heat into work, we have to deal with a substance at two different temperatures, and the work is done by the expansion of the substance against the external pressure of a piston by means of which the work is accomplished—thermo-electric engines being as yet possible, but not actual sources of supply.

* Cardew, "Proceedings of the Society of Telegraph-Engineers and Electricians," vol. ii., p. 301.

Thus, in a hot-air engine, heat is applied to air enclosed in one part of a cylinder; this air expands and drives back a piston, so doing work and losing its heat. If the air is further cooled on expanding by means of a refrigerator, a greater amount of work may be done, the amount being directly proportional to the difference of temperature of the air in its hot and cooled state—*i.e.*, the work done is proportional to $(T - t)$. The efficiency of the engine is the ratio of this work to the total heat given to the air—*i.e.*, if T is temperature from absolute zero, the efficiency of the engine is $\frac{T - t}{T}$. Hence the efficiency of such an engine depends on the difference of temperature through which it works,

By the second law of energy, or thermo-dynamics, it is established that in all heat-engines the work which a given quantity, Q, of heat can actually produce is $Q \times \frac{T - t}{T}$, or the efficiency of all such engines cannot be greater than $\frac{T - t}{T}$.

Now, in the steam engine the temperature of vapour in the cylinder is somewhat less than in the boiler, and some portion of the heat is lost by conduction and by friction; also the pressure of steam increases so rapidly with temperature, that the temperature attainable is limited from the danger of explosion of the boiler. By employing superheated steam separated from the water in the boiler, a higher temperature may be attained, and the efficiency of the engine greatly increased. For high-pressure engines the usual temperature is not higher than 150° C., so that the range of temperature is only about 100° C., and the efficiency certainly less than $\frac{100}{423}$, or ·236, *i.e.*, less than 24 per cent. This is the greatest efficiency which would be possible in a perfect engine, working between the temperatures of 150° C. and 50° C., supposing the temperature of the steam to be lowered by its expansion in the cylinder to the temperature of 50° C. This would mean that the steam must be allowed to expand to 26 times its original volume, which would be impracticable, and, if it were possible, would introduce other serious causes of loss of energy.

The temperatures between which steam engines have been actually worked are such as to give a theoretical efficiency of from 30 to 33 per cent., supposing the engines to be perfect engines, *i.e.*, engines in which all the heat applied is converted into useful work. The actual efficiency is very much less than this: the best steam engines have only a practical efficiency of from 10 to 13 per cent.

The question whether the hot-air engine will offer greater advantages than the steam engine must depend upon whether it can be worked at a very high temperature or not, for only in that case can its efficiency be greater.

With the Stirling hot-air engine the temperature is such that a pressure of about 37 lbs. per square inch is obtained, and the efficiency has been found to be about 30 per cent. But the difficulties of heating the air, without raising the temperature of the cylinder so high that it was burnt out, have prevented this engine from being much used.

Gas Engines.—In connection with the production of electrical energy, considerable attention has for some time past been given to another form of heat engine, in which an explosive mixture of ordinary coal gas with air is compressed and then exploded inside a cylinder. By this means very high temperatures may be reached, and hence a considerable amount of efficiency may be expected to be attained.

In the working of the Otto gas engine, the forward motion of the piston draws in air and an explosive mixture of air and gas; then the return of the piston compresses this mixture into less than half the length of the cylinder, the charge is then ignited and the explosion takes place, raising the temperature and pressure to their highest value; the piston is driven forward, and the pressure falls, then on the return stroke the exploded mixture is driven out of the cylinder. The work done in the explosion and expansion of the gases occupies less than a quarter of the period of two revolutions.

In the Clerk gas engine a second cylinder is added to supply the explosion cylinder with the explosive mixture, so as to get an explosion at every revolution. During the explosion and expansion in the explosion cylinder a piston has been drawing in first air and gas and then air into the second or displacer cylinder, and at the beginning of the return stroke they are driven into the explosion cylinder, the air first to clear out the used gases, and then the explosive compound, which is compressed at the end of the stroke to a pressure of nearly three atmospheres. The explosion then takes place, raising the temperature and the pressure to their highest value, and the piston is driven forward.

In these gas engines, although there is great loss of heat through the cylinder, which must be surrounded with a water jacket with a constant supply of cold water, yet the form of the curve of pressure keeps nearly up to the isentropic line, as if no heat were allowed to escape. This is accounted for by supposing that the temperature of dissociation of the gases is reached, or that at the temperatures reached a portion of the gas is dissociated, which enters into combination again when the pressure is gradually diminished by the forward motion of the piston. In this way the gas gradually burnt supplies the heat lost through the sides of the cylinder. Now the temperature may possibly reach to 1,800° or 2,000° C., and indeed in gas engines has been found to reach 1,530° C.; hence considerable efficiency may be attained, notwithstanding the fact that the exploded mixture would have its pressure somewhat diminished by an amount depending upon the contraction in volume of the gases forming the explosive mixture when they are exploded under constant pressure. With hydrogen, or with a mixture of hydrogen and carbonic oxide only, burnt in oxygen, this contraction would amount to one-third of the whole. and so the pressure attained would only be two-thirds of the pressure, supposing there were no contraction. If other gases are mixed with these, as in ordinary gas, then the pressure will not be so much reduced from this cause, but there will always be some such reduction from the pressure which would otherwise be attained when the gases are exploded. Were there no dissociation, a very much higher temperature would be attained than is actually observed in gas engines.

Making the supposition that the highest temperature reached is about 1,530° C., and that explosion takes place at once through the whole of the space occupied by the gas, the pressure at the first instant after explosion would be five or six times the pressure before explosion. If the gases be compressed to a pressure of nearly three atmospheres before explosion, the pressure of the exploded mixture is at first about fifteen atmospheres at a temperature of 1,500° C. Supposing that the expansion of the exploded gases is allowed to continue until the pressure is equal to the pressure of the atmosphere, the volume of the expanded gases would be more than six times their volume before expansion; and the temperature of the mixture, supposing no heat to have been lost through the walls of the cylinder, would be reduced to about 370° C.

As it would be inconvenient to go beyond the volume at which the mixture before explosion was at atmospheric pressure—*i.e.*, where the ratio of volumes is 3 to 1—under these circumstances the temperature at which the products would be discharged from the cylinder would be about 1,060° C. Taking into account the loss of heat by conduction and friction, the temperature would be considerably lower. This would give an efficiency of about 25 per cent. With very high temperatures, such as those in gas engines, the loss through the side of the cylinder must be very great, for the cylinder must be kept cool in order that the piston may work

in it, so that it is impossible to make use of the principle of the regenerator in this form of gas engine to heat up the entering gases.

Let me illustrate my remarks on this subject by some results obtained from the experimental tests made on gas engines at the Crystal Palace.

Assuming the values given by Mr. Clerk, in his paper before the Institution of Civil Engineers, for the heat evolved on the combustion of ordinary gas, we may arrive at the practical efficiency of the Otto gas engine. One pound of gas at 17° C. measures 35·5 cubic feet, and evolves on combustion 12,500 units of heat.

Now, in the Crystal Palace experiments, with the 12 H.P. Otto gas engine, the quantity of gas used per hour was 533·4 cubic feet, or 15 lbs. Hence the heat absorbed per minute is $\frac{12500 \times 15}{60}$, or 3,125 units.

The work done per minute upon the piston (which is 12 inches in diameter, and has a 16-inch stroke), at the rate of 158·7 revolutions per minute, with a mean pressure of 62·2 lbs. on the square inch, is $\frac{158{\cdot}7}{2} \times 62{\cdot}2 \times \frac{4}{3} \times \frac{22}{7} \times 36$, or 744,800 units of work. This is equivalent to 536 units of heat. Hence the theoretical efficiency is $\frac{536}{3125}$, *i.e.* ·1715 or 17 per cent.

The available indicated H.P. is 22·56, and the H.P. as shown by the Froude dynamometer is 18·31.

Hence the practical efficiency = $\frac{1831}{2256} \times {\cdot}1715 =$ ·1392, or 14 per cent.

The gas used per brake H.P. is 29·1 cubic feet.

With the 16 H.P. gas engine the quantity of gas used per hour was 841·6 cubic feet, or 23·71 lbs.

Hence the heat used up per minute is $\frac{12500 \times 23{\cdot}71}{60}$, or 4,940 units; the diameter of piston being 13 inches, length of stroke, $1\frac{3}{4}$ feet, mean pressure 63·08 lbs. per square inch, revolutions 151.37 per minute.

The work done per minute upon the piston is—

$$\frac{151{\cdot}37}{2} \times \frac{7}{4} \times 63{\cdot}08 \times \frac{22}{7} \times \left(\frac{13}{2}\right)^2,$$ or 1,109,000

units of work, which is equivalent to 798 units of heat.

Hence the theoretical efficiency is ·1615, or 16 per cent.

The available indicated H.P. is 33·6.

The H.P. on the brake dynamometer is 27·75.

Hence the practical efficiency is $\frac{2775}{3360} \times {\cdot}1615$, *i.e.*, ·1334, or $13\frac{1}{3}$ per cent.

The gas used per brake H.P. is 30·3 cubic feet.

It will be seen that 82·6 of the indicated H.P. appears on the dynamometer.

With the 2 H.P. Otto gas engine, the quantity of gas used per hour was 95·8 cubic feet, or 2·7 lbs.

Hence the heat generated per minute is $\frac{12500 \times 2{\cdot}7}{60}$, or 562·5 units.

The diameter of the piston is 5·75 inches, length of stroke 1 foot, mean pressure 54·31 lbs. per square inch, revolutions 160·3 per minute.

The work done per minute upon the piston is

$$\frac{160{\cdot}3 \times 1 \times 54{\cdot}31 \times 22 \times (5{\cdot}75)^2}{2 \times 7 \times 4} = 113{,}100$$ units of work nearly, which is equivalent to 81·37 heat units, or to 3·42 H.P.

Hence the theoretical efficiency is ·1446, or $14\frac{1}{2}$ per cent.

The H.P. on the brake or dynamometer is 2·87.

Hence the practical efficiency is $\frac{287}{342} \times {\cdot}1446$, *i.e.*, ·1214, or 12 per cent.

The gas used per brake H.P. is 33·4 cubic feet.

It will be seen that 84 per cent. of the indicated H.P. appears on the dynamometer.

It would appear, then, from these results, that even in the early days of gas engines each of these gas engines is superior in practical efficiency to the very best steam engines.

It must be taken into consideration that these efficiencies depend upon the quality of the gas, so that if the gas used at the Crystal Palace was not of sufficiently good quality to yield 12,500 heat units per lb. on consumption, these estimates of efficiency are too low.

Experiments were made with both the Otto and the Clerk engines, with different quantities of gas and also with different loads on the dynamometer. In working with the Otto 16 H.P. engine with a full load, it was found that after some time the cylinder became so hot that no flame was required to inflame the gas. A series of diagrams was taken with no gas jet to explode the gas, the explosion being caused by the heat of the cylinder when the unexploded gases were compressed by the piston.

The Clerk engine was worked not only with a full load, but with a medium load and also with a light load.

The Froude's absorbtion dynamometer employed in these experiments was kindly lent, and its working was superintended during the experiments by Mr. R. H. Froude.

The available horse-power in the Otto gas engine and in the Clerk engine have been calculated from the indicator diagrams.

The following are the general conclusions with regard to the working of gas engines, which have been drawn from the consideration of a great many indicator diagrams, taken under different conditions :—

The pressure curve almost coincides with the isentropic line of gases.

With perfect ignition the rate of increase of pressure is very nearly uniform up to the maximum, which is reached in about the $\frac{1}{30}$th of a second.

That the maximum pressures obtained in successive strokes are not the same, nor the times required for the maximum.

That the latter halves of the pressure curves are identical, provided the maximum pressure is reached at any time during the first half of the stroke. This is the case, whether the explosion takes place promptly or slowly.

That the greatest amount of work is done when the maximum pressure is reached at the beginning of the stroke.

That, with a very hot cylinder, the heat developed on compressing the gases may be sufficient to cause the explosion without a flame to fire the gases, and that even the greatest pressure may be reached before the return stroke is finished.

That the greatest pressure reached in large and small engines is practically the same (considering the amount of compression), but that the time of reaching the greatest pressure is somewhat less in small engines than in large ones.

With higher compression of the gases before ignition, the maximum pressures are increased, and the efficiency of the engine is greatly increased.

A considerable amount of loss of energy may arise from not carrying the expansion far enough before discharging the exploded gases. In the Clerk engine, especially, these gases were discharged at too high a pressure and temperature. The higher compression, which is practicable on account of the greater number of explosions in a given time in this engine, should greatly add to its efficiency. The engine works far more regularly in consequence of having an explosion at every revolution.

The results of the tests and the form of the indicator diagrams agree best with the theory that in gas engines dissociation takes place in the cylinder, and the pressure is kept up by continued combustion of the gases as the temperature falls.

It was found that from the beginning of the rise of

pressure to the time of reaching the maximum pressure, except in certain special experiments when different quantities of gas were used, the interval was scarcely ever more than $\frac{1}{30}$th of a second, and was often not more than $\frac{1}{50}$th of a second. In exceptional cases the ignitions took place very late in the stroke, and the maximum pressures obtained were very much reduced.

In all the experiments with Crossley's Otto engine (whether large or small), the maximum pressures were higher as the time of reaching the maximum was diminished.

There are manifestly two very great defects in gas engines—1. One-half of the heat resulting from the explosion of the gases passes away through the sides of the cylinder, and is thus entirely lost in heating the cylinder. 2. The exploded gas is discharged from the engine at a temperature of about 1,000° C. or 900° C., and so carries away with it a very large portion of the remainder of the heat due to the explosion of the gases.

As pointed out by Sir William Siemens in the discussion on "Gas Engines" before the Institution of Civil Engineers, this heat should be saved by communicating it to the incoming gases, so that their temperature before combustion should be 1,000° C. instead of 60° C. This is impracticable in the present form of gas engine in which a piston works within the cylinder. In 1860, Sir William Siemens had constructed a gas engine in which compression was employed, and in which the heat from the used-up gases was communicated to the incoming gases, thus carrying out the principle, which with him was of universal application, of using up, as far as possible, energy which would otherwise escape as wasted energy. In this engine the combustion of the gases took place as they entered a cylinder under compression, without working a piston: the cylinder could be kept hot, so that the heat of the gases would not be lost.

Efficiency of Dynamo Machines.—Having considered the efficiency of steam engines and other heat engines, by means of which heat may be converted into energy of motion or mechanical work, I wish now to consider the conversion or transformation of mechanical work into electrical energy by means of dynamo machines, and to illustrate my remarks by the results of the experimental tests of dynamo machines made at the close of the Crystal Palace Exhibition.

In this, as in other branches of the subject, accurate measurements and practical applications react on theoretical investigations in supplying the instruments and the means of progress. The dynamo machine has supplied the means of testing and working out its own theory; and even the Edison machine may be improved, when the theoretical and practical knowledge of a Hopkinson are brought to bear upon it.

In the electric circuit of a dynamo machine with an internal resistance, a (the armature) and f (the field), and external resistance, r, the whole arranged in simple circuit, we have, by Ohm's law, $\mathrm{E} = \mathrm{C}\,(a + f + r)$, and the difference of potential, p, at the terminals of the machine, $p = \mathrm{C}\,r$. The electrical energy in watts $= \mathrm{E\,C}$ or $= \mathrm{C}^2\,(a + f + r)$. This is converted into heat.

For shunt dynamo machines the total current, C, is the sum of the currents in the field magnets, C_1, and in the external circuit, C_0. The E.M.F. of the machine $\mathrm{E} = \mathrm{C}\left(a + \frac{f\,r}{f + r}\right)$, and the electrical energy in watts, E C, since $\mathrm{C} = \mathrm{C}_0 + \mathrm{C}_1$. The electrical energy spent in heating the armature $= \mathrm{C}^2\,a$. The electrical energy or heat in the magnets $\mathrm{C}_1^2 f$. The electrical energy in the external circuit $= \mathrm{C}_0^2\,r$ where $p = \mathrm{C}_1 f = \mathrm{C}_0\,r$.

The work applied to the dynamo machine must be determined by a transmission dynamometer. The *electrical efficiency* of the dynamo is the ratio of the total electrical energy to the total energy absorbed, deducting the energy spent on the friction of the driving shaft.

Of the total electrical energy produced, one portion is spent in heating the wire of the armature and field magnets, and is therefore wasted; the remainder is spent on the external circuit, and is the only portion which can be converted into useful work. The ratio of this external electrical energy to the total energy absorbed may be termed the *useful electrical efficiency* of the machine. In order to determine the efficiency of a machine, (1) the internal resistances of the armature and field should be determined. (2) The difference of potential at the terminals. (3) Either the current or the external resistance. Then the external resistance or the current respectively may be deduced from Ohm's law, and the electrical energy in *watts* may be determined.

In the Crystal Palace experiments the *difference of potential* at the terminals was found by charging a condenser from them and discharging it through a high-resistance galvanometer, and comparing the deflection with the deflection obtained by charging the same condenser from a Clark's standard cell. *The current* was obtained, (1) By charging the condenser from the extremities of a given resistance, consisting of several branches forming part of the circuit. (2) By means of a tangent galvanometer placed in one of these branches, whose resistance was known. The work absorbed per second was determined, and is expressed in watts, so that it may be readily compared with the electrical energy.

In the table of efficiencies, when three values are given for the current in any dynamo machine, the first is the value given by the tangent galvanometer, and the third by the condenser, the middle value being the mean of the two values so determined.

(*To be continued.*)

SOME RELATIONS OF HEAT TO VOLTAIC AND THERMO-ELECTRIC ACTION OF METALS IN ELECTROLYTES.

By G. GORE, F.R.S., LL.D.

THE experiments described in this paper throw considerable light upon the real cause of the voltaic current. The results of them are contained in twenty tables; and by comparing them with each other, and also by means of additional experiments, the following general conclusions and chief facts were obtained.

When metals in liquids are heated, they are more frequently rendered positive than negative in the proportion of about 2·8 to 1·0; and whilst the proportion in weak solutions was about 2·29 to 1·0, in strong ones it was about 3·27 to 1·0, and this accords with their thermo-electric behaviour as metals alone. The thermo-electric order of metals in liquids was, with nearly every solution, whether strong or weak, widely different from the thermo-electric order of the same metals alone. A conclusion previously arrived at was also confirmed, viz., that the liquids in which the hot metal was thermo-electro-positive in the largest proportion of cases were those containing highly electro-positive bases, such as the alkali metals. The thermo-electric effect of *gradually* heating a metal in a liquid was sometimes different from that of *suddenly* heating it, and was occasionally attended by a reversal of the current.

Degree of strength of liquid greatly affected the thermo-electric order of metals. Increase of strength usually and considerably increased the potential of metals thermo-electro-negative in liquids, and somewhat increased that of those positive in liquids.

The electric potential of metals, thermo-electro-positive in weak liquids, was usually about 3·87 times, and in strong ones 1·87 times as great as of those which were negative. The potential of the strongest thermo-electric couple, viz., that of aluminium in weak solution of sodic phosphate, was ·66 volt for 100° F. difference

* Read before the Royal Society, Nov. 22nd 1883.

of temperature, or about 100 times that of a bismuth and antimony couple.

Heating one of the metals, either the positive or negative, of a voltaic couple, usually increased their electric difference, making most metals more positive, and some more negative; whilst heating the second one also, usually neutralised to a large extent the effect of heating the first one. The electrical effect of heating a voltaic couple is nearly wholly composed of the united effects of heating each of the two metals, separately, but is not, however, exactly the same, because whilst in the former case the metals are dissimilar, and are heated to the same temperature, in the latter they are similar, but heated to different temperatures. Also, when heating a voltaic pair, the heat is applied to two metals, both of which are previously electro-polar by contact with each other as well as by contact with the liquid; but when heating one junction of a metal and liquid couple, the metal has not been previously rendered electro-polar by contact with a different one, and is therefore in a somewhat different state. When a voltaic combination, in which the positive metal is thermo-negative, and the negative one is thermo-positive, is heated, the electric potential of the couple diminishes, notwithstanding that the internal resistance is decreased.

Magnesium in particular, also zinc and cadmium, were greatly depressed in electromotive force in electrolytes, by elevation of temperature. Reversals of position of two metals of a voltaic couple in the tension series by rise of temperature were chiefly due to one of the two metals increasing in electromotive force faster than the other, and in many cases to one metal increasing and the other decreasing in electromotive force, but only in a few cases was it a result of simultaneous but unequal diminution of potential of the two metals. With eighteen different voltaic couples, by rise of temperature from 60° to 160° F., the electromotive force in twelve cases was increased, and in six decreased, and the average proportions of increase for the eighteen instances was ·10 volt for the 100° F. of elevation.

A great difference in chemical composition of the liquid was attended by a considerable change in the order of the volta-tension series, and the differences of such order in two similar liquids, such as solutions of hydric chloride and potassic chloride, were much greater than those produced in either of those liquids by a difference of 100° F. of temperature. Difference of strength of solution, like difference of composition or of temperature, altered the order of such series with nearly every liquid; and the amount of such alteration by an increase of four or five times in the strength of the liquid was rather less than that caused by a difference of 100° F. of temperature. Whilst also a variation of strength of liquid caused only a moderate amount of change of order in the volta-tension series, it produced more than three times that amount of change in the thermo-electric tension series. The usual effect of increasing the strength of the liquid upon the volta-electromotive force was to considerably increase it, but its effect upon the thermo-electromotive force was to largely decrease it. The degree of potential of a metal and liquid thermo-couple was not always exactly the same at the same temperature during a rise as during a fall of temperature; this is analogous to the variations of melting and solidifying points of bodies under such conditions, and also to that of supersaturation of a liquid by a salt, and is probably due to some hindrance to change of molecular movement.

The rate of ordinary chemical corrosion of each metal varied in every different liquid; in each solution also it differed with every different metal. The most chemically positive metals were usually the most quickly corroded, and the corrosion of each metal was usually the fastest with the most acid solutions. The rate of corrosion at any given temperature was dependent both upon the nature of the metal and upon that of the liquid, and was limited by the most feebly active of the two, usually the electrolyte. The order of rate of corrosion of metals also differed in every different liquid. The more dissimilar the chemical characters of two liquids the more diverse usually was the order of rapidity of corrosion of a series of metals in them. The order of rate of simple corrosion in any of the liquids examined differed from that of chemico-electric and still more from that of thermo-electric tension. Corrosion is not the cause of thermo-electric action of metals in liquids.

Out of fifty-eight cases of rise of temperature, the rate of ordinary corrosion was increased in every instance except one, and that was only a feeble exception —the increase of corrosion from 60° to 160° F. with different metals was extremely variable, and was from 1·5 to 321·6 times. Whether a metal increased or decreased in thermo-electromotive force by being heated, it increased in rapidity of corrosion. The proportions in which the most corroded metal was also the most thermo-electro-positive one was 65·57 per cent. in liquids at 60° F. and 69·12 in the same liquids at 160° F.; and the proportion in which it was the most chemico-electro-positive at 60° F. was 84·44 per cent., and at 160° F. 80·77 per cent. The proportion of cases therefore in which the most chemico-electro-negative metal was the most corroded one increased from 15·56 to 19·23 per cent. by a rise of temperature of 100° F. Comparison of these proportions shows that corrosion usually influenced in a greater degree chemico-electric rather than thermo-electric actions of metals in liquids. Not only was the relative number of cases in which the volta-negative metal was the most corroded increased by rise of temperature, but also the average relative loss by corrosion of the negative to that of the positive one was increased from 3·11 to 6·32.

The explanation most consistent with all the various results and conclusions is a kinetic one:—That metals and electrolytes are throughout their masses in a state of molecular vibration. That the molecules of those substances, being frictionless bodies in a frictionless medium, and their motion not being dissipated by conduction or radiation, continue incessantly in motion until some cause arises to prevent them. That each metal (or electrolyte), when unequally heated, has to a certain extent an unlike class of motions in its differently heated parts, and behaves in those parts somewhat like two metals (or electrolytes), and those unlike motions are enabled, through the intermediate conducting portion of the substance, to render those parts electro-polar. That every different metal and electrolyte has a different class of motions, and in consequence of this they also, by contact alone with each other at the same temperature, become electro-polar. The molecular motion of each different substance also increases at a different rate by rise of temperature.

This theory is equally in agreement with the chemico-electric results. In accordance with it, when in the case of a metal and an electrolyte, the two classes of motions are sufficiently unlike, chemical corrosion of the metal by the liquid takes place, and the voltaic current, originated by inherent molecular motion under the condition of contact, is maintained by the portions of motion lost by the metal and liquid during the act of uniting together. Corrosion, therefore is an effect of molecular motion, and is one of the modes by which that motion is converted into and produces electric current.

In accordance with this theory, if we take a thermo-electric pair consisting of a non-corrodible metal and an electrolyte (the two being already electro-polar by mutual contact), and heat one of their points of contact, the molecular motions of the heated end of each substance at the junction are altered; and as thermo-electric energy in such combinations usually increases by rise of temperature, the metal and liquid, each singly, usually becomes more electro-polar. In such a case the unequally-heated metal behaves to some extent like two metals, and the unequally heated liquid like two liquids, and so the thermo-electric pair is like a feeble chemico-electric one of two metals in two liquids, but without corrosion of either metal. If the metal and liquid are each, when alone, thermo-electro-positive, and if when in contact, the metal increases in

positive condition faster than the liquid by being heated, the latter appears thermo-electro-negative, but if less rapidly than the liquid, the metal appears thermo-electro-negative.

As also the proportion of cases is small in which metals that are positive in the ordinary thermo-electric series of metals only become negative in the metal and liquid ones (viz., only 73 out of 286 in weak solutions, and 48 out of the same number in strong ones), we may conclude that the metals, more frequently than the liquids, have the greatest thermo-electric influence, and also that the relative largeness of the number of instances of thermo-electro-positive metals in the series of metals and liquids, as in the series of metals only, is partly a consequence of the circumstance that rise of temperature usually makes substance—metals in particular—electro-positive. These statements are also consistent with the view that the elementary substances lose a portion of their molecular activity when they unite to form acids or salts, and that electrolytes therefore have usually a less degree of molecular motion than the metals of which they are partly composed.

The current from a thermo-couple of metal and liquid, therefore, may be viewed as the united result of difference of molecular motion (first) of the two junctions, and (second) of the two-heated—or cooled—substances; and in all cases, both of thermo- and chemico-electric action, the immediate true cause of the current is the original molecular vibrations of the substances, whilst contact is only a static permitting condition. Also that whilst in the case of thermo-electric action the sustaining cause is molecular motion, supplied by an external source of heat, in the case of chemico-electric action it is the motion lost by the metal and liquid when chemically uniting together. The direction of the current in thermo-electric cases appears to depend upon which of the two substances composing a junction increases in molecular activity the fastest by rise of temperature, or decreases the most rapidly by cooling.

NOTES.

Electric Lighting.—The New York *Economist* states that parties in Iowa City are arranging to operate electric lighting machinery for lighting the town by a valuable water power on the Iowa River, which was recently surrendered by a large paper company upon its removal to Indiana. The place is five miles distant from Iowa City, and the proposal is to transmit the electricity that distance by wire.

A Melbourne correspondent informs the writer of the dramatic notes in the *Referee* that the first theatre in Australia to adopt the electric light has been the Melbourne Princess's, where "Impulse" is being successfully played.

The P. and O. s.s. *Massilia*, the second of four contracted for by Messrs. Caird & Co., of Greenock, went her trial trip on Wednesday, the 26th ult., running a six hours' consecutive trial, and obtaining the high speed of 16 knots, equal to 18½ miles per hour. The electric light is employed throughout the ship, and all recent improvements tending towards the comfort of passengers have been introduced. The *Massilia* leaves for Bombay on April 16th.

A Rochester experimentalist, says an American contemporary, solicits $20,000,000, or more capital, to carry out a gigantic electric-lighting scheme. His plan is to use the power of the great Horseshoe Falls of Niagara for working ten engines of 200,000 horse-power each. These, he thinks, will generate enough electricity to furnish light to the 65 American and Canadian cities with which they will be connected by an extensive system of underground wires.

The *Times*, in its notice of the coming Health Exhibition, has the following:—"The motive power will again be supplied by Messrs. Davey, Paxman, and Co., of Colchester, whose engines will be capable of developing 1,250 horse-power."

The latest application of electric light, says the New York *Economist*, is one of the most wonderful. Ever since its discovery railroad men and inventors have been trying to adapt it to use as a locomotive headlight. The trouble was in the oscillation of the great engine frame, which shook the carbons together. Some Ohio and Indiana men have invented a perfectly-balanced lamp to hold the carbons. It has been running for 30 days on the Pan Handle Railroad, between Bradford Junction and Indianapolis, and has been a success. It is run by a little engine and dynamo placed on the side of the locomotive back of the Westinghouse air brake. The engine is, of course, in constant motion, and fed direct from the boiler by an eighth-of-an-inch tap.

An important and interesting series of experiments in street electric lighting is, as we have notified on several occasions, in course of being carried out by the Wimbledon Local Board. The precise object of the experiments is to determine the best method of illuminating streets, and of distributing light by electricity, cost, of course, forming an important factor in the consideration. To this end the experiments, which will extend over some weeks, will be very exhaustive, the intention being to test every appropriate system. An engine and dynamo machine have been placed in position, and between one and a-half and two miles of streets are already lighted, overhead wires and incandescent lamps being used. Besides a variety of lamps, it is intended to try various modes of distributing light by means of shades and reflectors. The experiments are not under the control of any one connected with any electric light system or company, but are being carried out in a perfectly independent manner.

One of the finest examples of lighthouse construction the world possesses, says the *Electrical World*, is that at the entrance to Port Jackson, Australia, called Macquarie Light. It is a first order, 16-sided, dioptric, holophotal revolving white light, of the system of Fresnel, showing a flash of eight seconds in every minute, and having a range of 25 miles seaward. The gas and oil burners for use during clear weather have, with flames of 1½ in. diameter, an intensity of about 200 candles instead of 80 candles with the same diameter, as with the old type of burner originally intended. When these flames are at the focus there is a consumption of about 40 cubic feet per hour of 16-candle gas, and of good paraffin about one pint per hour, and it is estimated that the mean intensity of the flashes from the apparatus is about 40,000 candles, or about five times the intensity of the flashes of the old Macquarie Light. With the full power of the electric light (used in conjunction with the gas in hazy weather) at the focus, the mean intensity of the flashes in the direction of the sea horison is not less than five or six million candles. By a single arrangement the change from gas light to electric light at the focus or the reverse, can be effected in 10 seconds, and the flames of the oil lamp can be substituted for the gas or electric light in nearly the same space of time. The Macquarie Light is intended only to illumine half the horizon. It is therefore possible to make use of the landward rays by means of a dioptric mirror. This is probably the first instance of the use of a dioptric mirror for an electric light. Arrangements are made to burn either gas or paraffin oil, or to exhibit the electric light at full power or half power. When the electric light is in use, there is always a second lamp in readiness for action.

It is stated that one of the best electric light systems was recently introduced into the Court Theatre at Stuttgart, and it was supposed that the orchestra would like it. But the orchestra have now petitioned the management to return to the old oil lamps, because the brilliancy of the electric light affects their nerves unpleasantly, and renders it difficult for them to follow the leader's baton. A committee of oculists and dis-

interested musicians has been appointed to inquire into the matter.

The German steamer *August*, which arrived at Granton last week from Memel, is fitted up with the electric light. The motive power is supplied from the steamer's machinery. The lamps are so fitted that the light from one lamp can be shown from the mast-head, and by means of connecting wires another can be fixed on the wharf for lighting up the warehouse alongside, thus enabling the cargo to be discharged and stowed by night. The total cost of fitting up the light was about £300.

On Wednesday the 26th ult, a most successful inauguration of the electric light took place at the Bethnal Green Branch Museum, in the presence of Colonel Festing, R.E., representing the Science and Art Department, and several of the directors of the "Pilsen Joel" and General Electric Light Company, the latter being the contractors for the work. The installation consisted of 28 "Pilsen" arc lamps, of 2,000 nominal candle power each, and 318 "Gatehouse" incandescent lamps, of 20 nominal candle power each; the motive power being derived from two 16-horse power stationary coupled engines, with multitubular loco-type boiler, by Messrs. Hornsby and Sons, Limited, of Grantham. The work, we understand, has been carried out in a most satisfactory manner, and reflects credit on the contractors, in whose factories at Kentish Town, the whole of the electrical plant, including dynamo machines, lamps, &c., &c., has been manufactured.

On the 26th ult, the lighting of a portion of the Armoury of the Tower of London by six "Pilsen" arc lamps, of 2,000 nominal candle power each, driven by one of the "Pilsen" Company's Dynamo Machines, was witnessed by Colonel Festing, R.E., and a number of the members of the staff of the Royal Engineers, &c. The lighting was a complete success.

The Electric Light in Devonshire.—At the ordinary general meeting of the Torquay Gas Company last week, Mr. W. H. Kitson, who presided, said the affairs of the company were in a satisfactory condition, emphasizing the point by alluding to the encouraging results of recent sales of shares, and by stating that during the past year the electric light had apparently made no headway. A suggested reduction in the price of gas had received consideration, but the directors did not feel that the present condition of their affairs would allow of any decrease.

Telephone Communication with Fire Stations.—"Observer," writing to the *Manchester Guardian* with reference to the value of the telephone for conveying speedy intelligence to fire stations, cites two remarkable instances which occurred in Manchester last week. News of the fire at the prison in Hyde Road, reached the fire station authorities first of all through the telephone at the works of Mr. Samuel Brooks, who is a subscriber to the Telephonic Exchange in Manchester, and placed thereby in direct communication with the Jackson's Row and Salford fire stations. Again, on Saturday evening, the alarming fire at Hope Hospital, Salford, was announced to the authorities at Salford fire station in the first instance by a telephone message transmitted from the residence of a gentleman in Eccles Old Road, in the vicinity of the hospital.

Telephony.—Some mischievous persons recently cut the wires in Wollaston Street, Nottingham, belonging to the National Telephone Company, and a reward of £5 has been offered for information leading to the conviction of the offenders.

New Telephone Lines in America.—Lewis E. Woods, E. F. C. Young, and James Vredenberg, three wealthy residents of Jersey City, have, according to the *Electrical World* (New York), incorporated the Hudson Telephone Company. The line of the company will begin at the Hudson River, and run through Jersey City and all the towns in Hudson County.

Telegraphy.—The *Standard* says a telegram has been received at the Siamese Legation that the new telegraphic route to Bangkok *via* Tavoy was opened on the 21st ult.

The Government of Victoria, says the *Colonies and India*, has decided to adopt the recommendation of Mr. Berry, the Postmaster-General: that in order to provide adequate telegraphic accommodation a storey shall be added to the General Post Office, Melbourne, at a cost of about £40,000.

Telegraph Extensions in Scotland.—An arrangement has been practically arrived at, through the instrumentality of Mr. Williamson, M.P., whereby the guarantee of the Barra fishery community for postal telegraphs will be reduced from £1,095 by the sum of £500. This sum of £500 will be paid as a grant from the Treasury to the Fishing Board of Scotland, through whose agency the arrangement, if assented to by those interested at Barra, will be carried out. Efforts are on foot to get a similar boon for the islands of Jura, Tiree, and Coll.

Foreign Telegraph Service.—Special telegrams to the *Standard* say:—The correspondents here and the public at home are equally under obligation to the Eastern Telegraph Company for the admirable and efficient service they have provided. On one occasion as many as twenty thousand words were tendered after sundown, and of these messages all London had the benefit next morning. The telegraph clerks at Berber have wired a joint message to the Khedive stating their wish to leave their present post, which, they say, has become an extremely dangerous one to hold.

Telegraphic Communication with South America.—The Brazilian Submarine Telegraph Company has repaired the cable between St. Vincent and Pernambuco, thereby restoring direct telegraphic communication with South America.

The managing director also announces the successful laying of the duplicate line between Madeira and St. Vincent. It is expected that the second cable between St. Vincent and Pernambuco will be laid by the middle of July, thus duplicating the company's entire system between Europe and Brazil.

Cable Repairs.—The Eastern Telegraph Company announce the repair of the Eastern and South African Company's cable between Mozambique and Delagoa Bay, thus re-establishing telegraphic communication with Natal and the Cape of Good Hope.

Spanish National Submarine Telegraph Company's Cables.—We are informed that the repairs of the Cadiz-Teneriffe section were successfully completed on the 24th ult. The s.s. *Dacia* met with very heavy weather during those repairs. We learn that she is expected to arrive in the Thames about the 7th inst.

Lighthouse Illuminants.—We hear that the Committee of the Trinity Board, appointed to conduct experiments with illuminants for lighthouses will shortly commence operations at the South Foreland, in testing the comparative value of electricity, gas and oil. Towers are now being erected for the lights on the cliff, to the landward of the lighthouses, and certain ranges marked off, about three miles distant as lines of observation, on which experiments are to be made at night time, extending over a period of some months.

Printing a Newspaper by Electricity.—We learn from an exchange that the Ilion, N. Y., *Citizen*, printed its entire edition of 3,000 copies on March 13th by

electricity, using an electric motor, deriving the current from a 10-light dynamo 15 rods away. It is the first newspaper in the country thus printed.

The Electric Railway at Brighton.—To-day, says the *Sussex Daily News* of Friday last week, the Works Committee of the Town Council will inspect the handsome new saloon car which Mr. Magnus Volk has nearly completed at the Paston Place arch for his electric railway along the Madeira Road. The car is without doubt a very fine one, and when on the rails must prove an ornament to the parade. It is beautifully furnished, and its polished mahogany framework, ornamented windows, and well-covered platforms, give it a very substantial appearance. The motive power will be placed in a concealed position underneath the car, and every precaution will be taken for perfect safety and comfort. When the whole of the apparatus is got into proper working order, as may be expected in less than a fortnight's time, the railway and cars—there are in addition two small lift cars and the old car improved—will very probably bear out all the conditions Mr. Volk claims for it.

City and Guilds of London Institute.—The report of the council of this institute has just been issued in a voluminous form, showing much good work done in the shape of technical education. Satisfaction is expressed with the progress made in the various departments, and that there is no sign of diminution in the interest manifested in the promotion of schemes for the advancement of the objects which the institute has in view. At the Finsbury Technical College there have been, since October last, 71 day students in electrical engineering, and 20 in mechanical engineering; 12 apprentices' tickets had been distributed in electrical engineering, and 32 in mechanical engineering. The lectures on electrical technology by Professor Ayrton, F.R.S.. and the laboratory instruction under his direction continue to attract large numbers of students, whilst there is a satisfactory increase in the attendance at the classes of Profs. Armstrong and Perry. At the Nottingham branch institution technical classes are now carried on in lace manufacture, carpentery, and joinery, mechanical engineering, electric light and transmission of power, iron and steel manufacture and telegraphy, and over 200 students are in attendance. A scheme is propounded in an appendix to the report for the organization of the central institution in course of construction, the object of which is to give to London a college for the higher technical education, in which advanced instruction shall be provided in those kinds of knowledge which bear upon the different branches of industry, whether manufactures or arts.

Electricity in Collieries.—At the annual meeting of the South Wales Institute of Engineers recently, the members present proceeded to discuss a paper on the transmission of power by electricity at the Trafalgar Collieries, which was read by Mr. W. Blanch Brain at the previous meeting. Mr. M'Murtie asked what saving Mr. Brain had effected by using electricity for pumping underground? In reply to Mr. Walker he said the use of electricity in gaseous mines would be attended with very great risk. Mr. Huxham inquired whether large quantities of electricity, which would be serviceable for ordinary colliery and manufacturing operations, could be transmitted to a distance economically and with useful effect. Mr. Walker said the danger of using electricity was entirely a question of accommodating the dynamo, and his idea was that it should be placed in a close chamber on the surface. Mr. Wilkinson said there was no doubt that electric sparks ignited gas. Mr. Walker remarked that supposing, as the machines were now constructed, the spark would light gas, it would be a simple matter of getting a machine to divide the spark indefinitely. Mr. Brain said it would not be difficult to prevent the sparks igniting gas. The dynamos were exceedingly small, and they could be entirely enclosed by a lid the same as a gas purifier. It was admitted that 70 per cent. could be got at the motor of the foot-pound put in at the generating station. Referring to Mr. Walker's suggestions, Mr. Brain said small motors could be worked in connection with fans very easily. The saving effected in his case was 80 tons of coal between Saturday night and Monday morning.—*Engineering.*

Building Trades Exhibition.—At the exhibition held during the last fortnight at the Agricultural Hall, Islington, electricity, though put forth as one item of the programme, was not very conspicuous. Still there were a few exhibits having an electrical connection more or less remote, which may be worth passing mention. The electric light was represented by two arc lights and a few score of incandescent lamps, principally distributed amongst the various displays of furniture and interior decorations. The current for these was a matter of private arrangement between the exhibitors and the Electric Supply and Fitting Company, who produced the necessary current by dynamos, driven by a portable engine from the Kingsbury Iron Works. There were also about a dozen lamps fed by a dynamo at the stand of Mr. Hindley, of Bourton, worked by one of his small vertical engines. At the stall of Messrs. Eck, Callow & Company, was shown an electrical burglar and fire alarm, which gives on either emergency a report sufficient to arouse the neighbourhood, and also a light which indicates the house and illuminates the whole street. The Imperial Stone Company exhibited hollow kerbing for telegraph, telephone, and electric light wires, and Mr. Curzon showed specimens of Banner's patent hollow concrete kerb for conveying telegraph and electric lighting wires, gas pipes, &c. A patent corrugated disc pulley made by Messrs. J. and E. Hall, appears to be worth the attention of electrical engineers, the makers claiming for it that it is unequalled for lightness, and that being perfectly balanced, it is peculiarily well adapted for high speed.

United Telephone Company of the River Plate, Limited.—It is notified that Mr. Alexis Mols, director of the Bell Telephone Manufacturing Company, Limited, and of the Compagnie Belge du Téléphone Bell, Antwerp, and Mr. Edward Weber, merchant, of London and Paris, have been elected directors of the United Telephone Company of the River Plate, Limited, and that the resignations of the chairman, Major Alexander Wood, and of Mr. R. M. Cunningham and Mr. Edward Zimmermann, directors, have been received and accepted.

Telpherage.—Professor W. E. Ayrton, F.R.S., recently delivered a lecture on Telpherage before the Royal Society, Dublin. There was a large attendance, the Lecture Theatre being crowded. We have already described the system in our pages, and need only add that Professor Ayrton's lecture evoked considerable interest.

The Calcutta Exhibition.—In the list of awards at the Calcutta Exhibition, telegraph and telephone wires have taken a prominent place. We are informed that Messrs. Ramsden, Camm & Co., of 72, King William Street, London, and Brighouse, Yorkshire, have received the highest award given for telegraph wire of high conductivity (lengths of single pieces of wire 100 to 140 lbs., free from welds), and telephone wire, single or stranded, high strain: and plain galvanized, as well as covered with woven-on cotton, and tarred. The exhibit of this firm comprised a handsome ebony and gilt case, containing samples of copper wire of purest quality, &c., and sections of many cables made by Siemens Brothers, of London, and the India Rubber, Gutta Percha, and Telegraph Works, Silvertown (for which firms R. C. & Co. have for many years past

manufactured cable covering wires), besides samples of wires drawn in thicknesses varying from half an inch to the three-thousandth part of an inch in diameter. Ramsden, Camm, & Co., are contractors to Her Majesty's Government, the East Indian Governments, the Agents General for the Colonies, and to many of our large home railway companies. At the present time they are engaged upon a contract with Her Majesty's Government for the supply of 1,000 tons of telegraph wire, in view of the cheapening of inland telegraphy. They take high rank in this class of wire, and make a speciality of their process for weaving on their cotton covering and their tarring of telegraph and telephone wire. They have within the last two years largely increased their plant, and are now in a position to cope with the largest contracts from time to time on our home market. The position so long held by this firm for high grade wire of every description in general use has been conceded also by the judges at the Calcutta Exhibition. We are informed that Mr. S. H. Byrne, who is the sole surviving partner in the old firm of Ramsden, Camm, & Co., has cordially presented the show case and contents, and as much of the stock of wire as may be desired (of which some tons were sent), as a contribution to a permanent museum, now, or about to be established in our great Indian dependencies.

The Brazilian Submarine Telegraph Company, Limited.—The issue of this company's tariff and regulations for the current year has just reached us, and we observe, in addition to the usual information as to the charges for transmission of messages and the rules affecting the same, an excellent map, showing the direction of the company's existing cable from London to South America, and of the duplicate cable now in course of construction from Madeira to Pernambuco.

The Queen v. the Postmaster-General.—This was an application by the Great Western Railway, made before Lord Coleridge and Mr. Justice Watkin Williams, on Friday last week, for a *mandamus* to the Postmaster-General to take proceedings to compensate the company for having, under the powers of the Act of 1868, taken the electric telegraph on one of their subsidiary lines of railway. The Attorney-General (with the Solicitor-General and Mr. Simpson) appeared for the Postmaster-General; Mr. Webster, Q.C., and Mr. R. S. Wright, were for the Great Western Railway Company. The case having been argued, Lord Coleridge said the court would take time to consider their judgment, which, however, they would deliver before Easter.

Brush Electric Light and Power Company, of Scotland, Limited.—Notice is given of a meeting of this company, to be held on the 29th inst., at Dashwood House, 9, New Broad Street, for the purpose of having an account presented showing the manner in which the winding-up has been conducted, and the property of the company disposed of, &c.

Underground Wires.—The *Philadelphia Times* of March 19th, details a visit of one of its reporters to the office of the Pennsylvania Railroad Company, which has abandoned the use of all its overhead telegraph wires except two. The working of the underground system, which is the invention of Mr. David Brooks, whose conductors are in use in London, was stated to be superior to that in which overhead wires are used, there being not the slightest evidence of induction in the telephone trials.

An Electric Railway Experiment.—We learn from the New York *Electrical World* that a railway has been built round the Brush Electric Light Works, in Cleveland, Ohio, for the purpose of testing a new electric motor for tramcars. The motor and electrical machinery are placed on the front end. The new motor, if successful, will probably be put in use on the tramcar lines in Cleveland.

Large Multiple Switch-boards.—The Western Electric Company, an exchange announces, has just completed a very large multiple switch-board for the Boston telephone exchange. It is an ornamental piece of work, and has a capacity for 4,200 wires. At present it is occupied by 2,000. This is one of the largest switch-boards manufactured, but the largest in operation is that made by the company for use at Baltimore, which is of the same height and one section longer, having a capacity for 4,900 wires. It is only occupied at present by 1,600 wires.

Faure Electric Accumulator Company, Limited.—Mr. Harcourt Turner has called a meeting of the shareholders in the Faure Electric Accumulator Company, Limited, to consider their position in view of the bankruptcy of affiliated Continental Companies, and of the proceedings taken against Messrs. Phillipart there.

Post Office.—Mr. Fawcett has re-introduced his bill for amending the law with respect to the protection of the Post Office and to offences committed in relation to the Post Office.

The "Werner" Arc Lamp.—Messrs. Latimer Clark, Muirhead & Co., Limited, are the sole agents and manufacturers in the United Kingdom for the "Werner" arc lamp, which is said to be of very simple construction, and which is well known on the Continent.

Personal.—We are sorry to hear that Mr. C. J. Simmons, the well known electrical instrument manufacturer, was badly hurt in the railway collision which took place at Stepney on the 22nd ult. We shall be glad to learn of Mr. Simmons' speedy recovery.

Withdrawal of Petition.—We are informed that the petition lodged by Messrs. Woodhouse and Rawson against the French Electrical Power and Storage Company, has been withdrawn, their claim being settled in full.

Stock and Share Auction and Advance Company, Limited.—At this company's sale on Thursday, shares of the Electric News Telegraph Company were disposed of at £2 10s. each; Gulcher Electric Light and Power Company's shares fetched 10s.

The Great Fire in Paternoster Row.—We have pleasure in informing our readers that, although at one time the flames threatened to overwhelm both our publishing and printing offices, no serious damage has been done to either of them. Had the fire occurred one night earlier, some of the blocks of the present issue would have been irretrievably lost, or had it happened a night later, a large portion of the type, as well as the blocks, would inevitably have been destroyed. As it is, we have reason to congratulate ourselves on the fact that but a small portion of our stock of paper, which was in Messrs. Pardon's hands, has been lost to us.

Failure in the India Rubber Trade.—We read in last Monday's *Times* of the failure of Messrs. Vianna & Co., of Havre, in the India Rubber trade. The firm has a house in Para, Brazil, but whether it is involved in the disaster is not known. The firm is understood to have been engaged in exceedingly large speculations, and from time to time have drawn bills for large amounts on some of the leading London houses. Little pity is felt for them in the trade, which was

harassed and inconvenienced by the great rise which occurred some little time ago in the price of this article owing to the operations of the firm.

An Improved Thermo-Electric Pile.—Dr. G. Gore, F.R.S., read a paper on February 14th, before the Birmingham Philosophical Society, on an improved thermo-electric pile for measuring small electromotive forces. The apparatus consists essentially of a series of about 300 pairs of horizontal, slender, parallel wires of iron and German silver, the former alone being covered with cotton. The wires are about 8 inches long, fixed side by side in close mutual contact, though insulated from each other, as a continuous flat layer about 16 inches long, in a wooden frame, and soldered end to end in single continuous series. About 1½ inch in length of the opposite ends of the wires are bent downwards to a vertical position, so as to enable them to dip into two liquids of different temperatures contained in two long, narrow troughs. The liquids employed are non-conductors; this was found to be necessary. The one for the hot junctions is melted paraffin kept at a temperature of 120° C., and the one for the cold ones is non-volatile petroleum, known by the name of "thin machinery oil." The ends of the wires are immersed about one-fourth of an inch in the liquids. The maximum power of the instrument is of course limited by the amount of difference of temperature of the two liquids, and of the two series of ends of wires immersed in them. Any lower degree of electromotive force is obtained by attaching a copper wire to one end of the series, and sliding the free end of the other terminal wire across the middle part of the upper surface of the wires, from that end of the series towards the other; the German silver wires being bare permit metallic contact, An apparatus as above described, consisting of 295 pairs of wires, had a resistance of 95·6 ohms at 16° C., and by a difference of 100° C. of temperature of the two baths, gave a current having an electromotive force of ·7729 volt, or with a difference of 130° C., 1·005 volt. Each element therefore equalled ·0000262 volt for each C. degree difference of temperature. After having been verified with a standard voltaic cell, such an apparatus (or any fraction of it) may itself be employed as a standard. It is capable of producing and measuring as small a degree of electromotive force as a 34861st part of a volt. When the potential of the currents to be measured exceeded one volt, either an additional pile or a standard voltaic cell was employed with it. Several apparatus of this kind have been constructed, and a large number of determinations of electromotive force have been made with them. Fifteen determinations per hour have frequently been made; the rate of working, however, depends upon the steadiness of the current to be measured.—*Nature.*

OFFICIAL RETURNS OF ELECTRIC COMPANIES.

Lancashire Maxim-Weston Electric Company, Limited.—At a meeting of the shareholders in the above company, held at the Cannon Street Hotel, on the 13th ult., the following resolutions were unanimously carried:—"That it has been proved to the satisfaction of this meeting, that the company cannot, by reason of its liabilities, continue its business, and that it is desirable to wind up the same, and accordingly that the company be wound up voluntarily." "That Thomas Whitworth, Esq., of 10, India Buildings, Cross Street, Manchester, and John Browne, Esq., of 3, Aubery Road, Holland Park, W., be and they are hereby appointed liquidators to wind up the company, and that they be paid each 50 guineas for their services as such liquidators, in addition to their travelling or other expenses." These resolutions were duly filed on the 27th ult.

Electropathic Association, Limited.—An extraordinary general meeting of the shareholders in this company, was held on the 26th ult. at the offices of Mr. Augustus Fleet, 39, Hatton Garden, when a resolution was passed to the effect that, it having been proved to the satisfaction of the meeting that the association cannot, by reason of its liabilities, continue its business, it should be wound up voluntarily, and that Mr. William Bradley Poublon, of 105, Guildford Street, Russell Square, be appointed liquidator. The resolution was duly filed on the 26th ult.

United Telephone Company of the River Plate, Limited.—The registered office of this company is now situate at 131, Wool Exchange, Coleman Street.

Electro Amalgamator Company, Limited.—An agreement, dated 14th ult., and registered 25th ult., states that the company has been very anxious to support the Hungarian Gold and Silver Reduction Works, Limited, and the directors of the latter company having failed to receive privately applications for more than 5,000 shares, some of the directors of the Hungarian Company were anxious to withdraw, and the board collectively declined to apply to the public for subscriptions unless a minimum subscription for a further 2,000 shares could be obtained prior to advertising. Accordingly, in the interest of the Electro Amalgamator Company, Limited, Mr. Robt. Steuart Gladstone undertook that, provided the said directors would publicly advertise for subscriptions, he would guarantee to subscribe for 2,000 shares, or for such portion thereof as the public might not subscribe for. It is therefore agreed that for every Hungarian share Mr. Gladstone shall be called upon to subscribe, the Electro Amalgamator Company will allot him a fully-paid share at a discount of 50 per cent., the money for the same to be applied in the payment of calls upon the Hungarian shares, it being intended that he shall receive a bonus in fully-paid shares of the company to one-half of the nominal amount to which he shall subscribe for shares in the Hungarian Company. The Hungarian shares to be allotted to Mr. Gladstone are to be transferred to the company. In the event of the public subscribing for such number of shares in the Hungarian company as will prevent Mr. Gladstone being called upon to subscribe, the company will allot him 200 fully-paid shares in consideration of his guarantee, or should the shares to be allotted be less than 400 bonus shares, representing £2,000 stock in the company, he is to have allotted to him such an amount of fully paid up shares, in addition to the bonus to which he shall have become entitled, as will make up such bonus to £1,000 fully paid stock in the Electro Amalgamator Company.

Provincial Telephone Company, Limited.—At a meeting of this company, held at 41, Queen Victoria Street, on the 5th ult., it was resolved to wind up voluntarily, and Mr. Wm. Birrell Campbell, of 11, Queen Victoria Street, was appointed liquidator. The resolution was confirmed on the 26th ult., and registered 28th ult.

CITY NOTES, REPORTS, MEETINGS, &c.

German Union Telegraph and Trust Company, Limited.

THE 13th ordinary general meeting of this company was held at the offices, 66, Old Broad Street, on Thursday, Sir James Anderson presiding.

The Secretary, Mr. William Payton, having read the notice convening the meeting, and the minutes of the previous meeting,

The Chairman moved the adoption of the report, which we published last week, and the declaration of a dividend of 6s. per share, making a total distribution for the year of 11s. 9d. per share, free of income tax, or at the rate of £5 17s. 6d. per cent. per annum, as against £5 5s. 10d. paid last year. In doing so, he

remarked that no repairs had been necessary since the last meeting, whilst there had been an increase of revenue. The main item in the report was, that they had spent £26 more this year than last, principally in getting new register books; and it was a most satisfactory fact that they had £42,500 on reserve, and also £20,500 unexpended capital. The only outlay of the last year had been in making a new station at Lowestoft, to replace that washed away during the gales. They were aware that another cable was laid from Valencia to Emden a year or two ago, and with the increase of revenue thus brought about they were enabled to pay a dividend of nearly six per cent., half per cent. more than last year; and, as far as could be judged, that prosperous state would continue, except, of course, in the event of any untoward circumstance such as submarine cables were liable to.

Mr. H. G. Erichsen seconded the adoption of the report, which was carried unanimously.

Mr. Erichsen was then re-elected a director, and Mr. Henry Dever auditor for the ensuing year, after which a vote of thanks to the board, moved by Mr. Griffiths, terminated the meeting.

The South-Eastern (Brush) Electric Light and Power Company, Limited.

AN extraordinary general meeting of this company was held at the Cannon Street Hotel, on Thursday, Sir Michael Kennedy presiding.

Mr. Alfred Jermyn, the secretary, read the notice convening the meeting, which was held to confirm a resolution passed on the 18th ult., reducing the capital from £100,000 in 20,000 shares of £5 each, to £51,000, consisting of 400 fully paid shares of £5 each, and 19,600 of £2 10s. each.

The Chairman: I beg to put the motion which has just been read.

Mr. Fry seconded.—Carried.

The Chairman: That terminates the business of the meeting.

The Australasian Electric Light, Power, and Storage Company, Limited.

AN extraordinary general meeting of this company was held on Friday, the 28th ult., at the offices, Coleman Street, Moorgate Street, to consider an agreement between the company and the Australian Electric Company, Limited.

Mr. Randolph C. Want presided, and congratulated the shareholders on the successful issue of the negotiations which had been going on so long for an amalgamation of the interests of the two companies.

The Secretary, Mr. J. H. Duncan, afterwards read an outline of the agreement.

According to a circular distributed to the shareholders, the result of the agreement would be that "all competition between the two companies will cease, as the amalgamated company will be left free to work Victoria alone, the local company retiring altogether from the other colonies, and constituting our company elsewhere in Australia its sole agents for the Swan Lamp." The circular also stated that, apart from the profits anticipated from the actual investment itself, the directors believed that important advantages would result from the arrangement.

On the motion of the Chairman, seconded by Mr. Latimer Clark, a resolution was passed authorising the agreement.

German-Norwegian Submarine Cable Company.—The dividend of 5¾ per cent. for 1883 (coupon No. 5), viz., Mark 23, equal to £1 2s. 5d. per share of Mark 400, or £20, is now payable at the offices of the German Union Telegraph and Trust Company, Limited, 66, Old Broad Street, E.C. The numbers are published of 52 shares of 400 marks each, which will also be paid on that date.

German Union Telegraph and Trust Company.—The dividend of 8¼ per cent. for 1883 on the ordinary shares (coupon No. III., second series), Marks 24·75, equal to £1 4s. 1d. per share of 100 Thalers, or £15, is now payable (less the interim dividend of 12 marks, or 11s. 9d.) at the offices of the agency, 66, Old Broad Street, E.C.

Hamburg-Heligoland Telegraph Company. — The dividend of 6¼ per cent. for 1883 (coupon No. I., second series), viz., Mark 19, equal to 18s. per share of 100 Thalers, or £15, is now payable at the offices of the German Union Telegraph and Trust Company, Limited, 66, Old Broad Street, E.C.

Eastern Extension Telegraph Company. — The Directors have declared a dividend of 2s. 6d. per share, together with a bonus of 3s. per share, making 7 per cent. for the year, against 6¼ per cent. for 1882. A sum of £50,076 is carried to reserve, which is thus raised to £462,821.

Stock Exchange.—Application has been made to the Committee to appoint a settling day in, and grant a quotation to, Anglo-American Brush Electric Light Corporation shares with £5 and £3 paid, in lieu of those quoted.

Western Union Telegraph Company.—A quarterly dividend of 1¾ per cent. is payable on the 15th inst.

TRAFFIC RECEIPTS.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of March was 3,851, estimated to produce £8,200, against 5,139 messages, producing £4,009 in the corresponding month of last year. The receipts for the month of December, estimated at £2,500, realised £2,559.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of March are £1,751, against £1,782 in the corresponding period of last year.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

AN ordinary general meeting of this Society was held on Thursday, March 27th, Professor W. G. ADAMS, President, in the chair.

The minutes of the last ordinary general meeting having been read and confirmed, and the list of new and proposed new members announced, the President stated that it was intended to form a committee in connection with the "Health Exhibition," it being proposed to hold conferences at which communications would be read and discussed; the subject of Electric Lighting was suggested as being a fitting one to be considered.

Mr. MASSEY then read a reply to the discussion which had taken place on his paper at the last ordinary general meeting. With regard to the President's remarks as to the excessive brilliancy of the electric lamps, he would point out that the latter were not intended to be looked at direct. He did not think that the balance between the expense of renewals and the general expense of the light need be made, as expense was not of so much importance as a good light. The objection to the lights being extinguished at stations when a train was being split up, was not worth consideration, as there would in such cases be plenty of light from the station lamps. In criticising Mr. Preece's compressed air system, he said that calculation would prove that such an arrangement would require 70 horse-power as against 7 by the direct system, that is to say, 240 lbs. of coal per hour would be required. The method adopted on the London and Brighton Railway would cost twice as much as the direct method. The fact that trains were broken up in sections, consisting of different numbers of carriages, made it very difficult to estimate the power which would be required to light by the primary battery system. With reference to Mr. A. Siemens remarks, he would point out that at the time the experiment referred to was made no experience had been gained on the subject. That the machinery would run for a lengthened time on the author's system was proved by the fact that the dynamo had not been cleaned for two months. He thought that it was unnecessary to speak of the merits of the Willan's engine as suggested by Mr. Crompton, as the engine practically spoke for itself by the excellence of its performance. The difficulty referred to by Mr. Spagnoletti of having through carriages which would have to run on several railways, applied just as much to the air-brake as to the electric lighting system, and no difficulty was experienced in the former. The experiments of Mr. Collett with secondary batteries tended, he thought, to delay rather than hasten the employment of the electric light in railway carriages. Secondary batteries never work well except in the hands of those who are financially interested in them. Making a general comparison of the cost of fitting the Great Western Railway plant with electric as against gas fittings, the former would cost a quarter of a million sterling, and the latter three quarters of a million.

A paper was next read by Professor G. FORBES, on "The proportion which ought to subsist between the Size of Conductors and the Strengths of Currents."—The heating which took place in electric conductors when transversed by strong currents might be very great and would tend to destroy the insulation, and to cause fires. The author had searched but had been unable to find any records of the subject having been considered, or of any practical results being obtained. Looking to the future, he would take as a starting point, a conductor which would have to convey 70,000 ampères of current. This might seem to be a very excessive amount, but when we consider that some of the gas companies employ 4 foot mains, it was not unreasonable to suppose that such large conductors might actually be required. The idea of employing small conductors with accumulators was as reasonable as charging gas holders by small mains with the gas at a high pressure. To have safety it had been again and again stated that the conductor should carry so much current per square inch of section, such an idea was perfectly absurd and erroneous. In many cases if the law stated were followed, the conductors would become red hot. According to a table calculated by Mr. Welch, 2,700 ampères was laid down as the limit of safety; Mr. Andrew Gray gave 5,000 ampères, neither of these figures were however correct. Sir William Thomson's law was, as had been before pointed out, erroneous. The various cases to be considered in determining the size of conductors were five in number, viz: —Overhouse bare wires; overhouse cables; subterranean wires; subaqueous wires; and coils. In aerial cables the maximum amount of heat is arrived at at once, but in buried wires the heat might go on increasing for days. The only two investigators who had paid any attention to the subject of the heating of wires were Messrs. Day and Gray, the latter gentleman had gone into the

question of the heating of covered wires. The general law that the heating of a wire when the radiation was free varied as the current squared and the diameter cubed, did not appear to be verified by experiment, possibly because in small wires the cooling of the surface would be greatly affected by air currents. One ampère per 10 lbs. of copper per mile had been suggested as a safe current, and Mr. A. Jamieson had stated that 1,000 ohms per volts of electromotive force would be sufficient insulation.

The law connecting the current strength with the diameter of the wire had been stated as follows:—

$$C^2 = D^3 t . \frac{\pi^2 H}{4 R \times 0{\cdot}24}$$

where C = current; D = diameter of wire; t = excess of temperature; H = coefficient of radiation and convection; R = specific resistance; ·24 = number of Gramme centigrade heat units in a watt. Experiments made by Mr. Edmunds had proved, as might be expected, that if a wire was flattened so as to expose a larger surface, the less would be the temperature to which it would rise. In order to verify the law

$$C^2 \propto D^3$$

a number of lengths of wire of different gauges were heated by a current, the latter being increased until some beeswax which was in contact with the wire just melted; the result seemed to prove that the law

$$C \propto D$$

was nearest to the truth, the result being no doubt due to the effects of currents of air being greater on small wires than on large. The current required to fuse a wire depended upon the length of the latter, owing to the heat carried off by the clamps between which the wire was secured; to obtain accurate results the length ought to be at least 300 times the diameter. The results of some experiments by Mr. Preece on the fusing of wires, which had been communicated to the Royal Society, confirmed the irregularity of the law. The formulæ which expressed the rise of temperature in an aerial wire was

$$C = \pi r_1 \sqrt{\frac{k t}{\cdot 12 R \log. \frac{r_2}{r_1}}}$$

and

$$t' = \frac{k t}{e r_2 \log. \frac{r_2}{r_1}}$$

where e was the coefficient of cooling, whose value was ·0003; and k the conductivity to heat of the insulation, the value for gutta percha being ·0004. It might have been thought the envelopement of a wire by a bad heat conductor would have retarded the cooling of the wire, but just the reverse was the case, owing to the surface exposed being rendered larger, so that the radiation can take place more freely; this is fully borne out by experiment, and consequently a covered wire will carry with safety a greater current than an uncovered one. The questions concerned in the general subject are really those of the flow of *heat* and not electricity. When a current flows and heats a wire, the rise of heat is gradual up to the point at which the influx and outflow become equal; the electrical resistance of the wire is therefore low at first, and gradually increases. In an actual experiment it was fouud that an ½-inch conductor, covered with an insulating substance two inches thick, carried a current of 800 ampères; this was greatly in excess of the theoretical amount, but in this case the current had only been kept on for a comparatively short time, so that the maximum temperature had not nearly been arrived at. It had been suggested, and the idea had been patented, that a small wire, embedded in plaster of paris, might be used to convey strong currents; this notion was, however, entirely erroneous. With further reference to the experiment alluded to, in which a current of 800 ampères was conveyed through a ½-inch conductor, calculation proved that it would take 32 minutes for the wire to become heated to its maximum temperature, supposing that no loss took place whilst the temperature was rising; but, as a matter of fact, the heat would be continually flowing out, so that the time which the wire would take to arrive at the permanent state of temperature would be very much longer than the time stated. A very thin flat conductor, heavily insulated, would keep cool for a very long period when traversed by a strong current. Taking the case of subterranean conductors, the heat would take place upwards through the soil; if the conductor were buried two feet deep, and its dimensions were 2,800 centimetres broad by one centimetre thick, this, when traversed by 70,000 ampères of current, would not heat the surface of the ground more than 10° above its normal temperature. A plate 360 centimetres wide would carry a current of 9,000 ampères. Iron would probably prove cheaper than copper. If we compare the sizes of wire for aërial bare wires, aërial covered wires, and subterranean wires, the widths should be as 1,405, to 4,256, to 2,800 centimetres for 70,000 ampères of current. In order that the temperature may not be increased more than 50°, we must have—

$$C = \cdot 25 \sqrt{\frac{\text{Surface}}{\text{Resistance}}}$$

The meeting then adjourned.

NEW PATENTS—1884.

5502. "Transmission of speech." C. E. ALLEN. Dated March 26. (*Complete.*)

5510. "Printing telegraphs." W. R. LAKE. (Communicated by A. F. Johnson.) Dated March 26.

5544. "Voltaic battery." C. W. STEWART, G. H. HARRISON. Dated March 27.

5572. "Laying and protecting underground wires for telegraphic, telephonic, electrical lighting, and other electrical purposes." J. B. PASH. (Communicated by T. R. James. Dated March 27.

5573. "Electrical suspensors or suspensory bandages." C. B. HARNESS. Dated March 27.

5612. "Telephone transmitters." W. MOSELEY. Dated March 28.

5623. "Telephonic apparatus and circuits." T. PREECE, P. LOFTUS. Dated March 28.

5624. "Electric mains employed in district lighting." J. E. H. GORDON. Dated March 28. (*Complete.*)

5653. "Constructing armatures of dynamo machines." E. J. PATERSON. Dated March 29.

5670. "Arrangement of circuit connections for electric lighting." H. EDMUNDS. Dated March 29.

5674. "Electro metallurgical process of manufacturing electrical conducting wires and rods." J. B. SPENCE. Dated March 29.

5681. "Electric high and low water alarm for steam boilers." G. W. SOUTHEY, W. H. RUSDEN. Dated March 29.

5684. "Dynamo-electric machines." G. F. REDFERN. (Communicated by P. A. A. M. A. Favier.) Dated March 29.

5690. "Current-regulating devices for use in the circuits of electric lamps or other apparatus." S. F. WALKER, F. G. OLLIVER. Dated March 29.

5695. "Safety 'cut outs' for electric lighting and other electric circuits." A. W. BREWTNALL. Dated March 31.

5702. "Applying electricity to the human scalp by means of an improved construction of hair brushes, rotary or hand." W. TAPP. Dated March 31.

5716. "Measuring the quantity, pressure or energy of electric currents." A. WRIGHT. Dated March 31.

5719. "Microphones." F. J. SEMAL. Dated March 31.

5738. "Printing telegraphic apparatus." J. A. MUNIER. Dated March 31.

5757. "Insulating supports for electric wires for telegraph, telephone and other purposes." B. PITT. Dated April 1.

5781. "Electro-magnetic magnetic (*sic*)." N. ROLLAND, S. VYLE. Dated April 1.

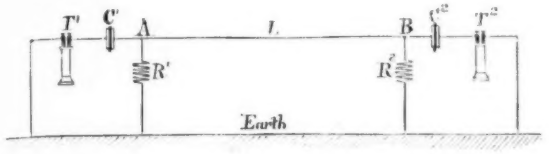
5807. "Method of railway signalling by automatic electric lanterns or semaphores." C. D. TISDALE. Dated April 1.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1883.

3575. "Voltaic batteries." W. R. LAKE. (Communicated from abroad by J. M. Stebbins, of America.) Dated July 20. 6d. Relates to improvements in electric batteries, and its object is to provide a battery which shall be practically constant for an indefinite length of time, and at the same time furnish a maximum of motive force during its existence. In carrying the said invention into practice, the inventor provides a cell of India rubber or any suitable vitreous material and a cover, which is made to fit as nearly air-tight as possible. He also provides an interior cup or cell closed on all sides except at the top; this cup is made of any non-porous material, except certain portions between the plates. The carbon plates are suspended in the said cup so as to be submerged in the exciting solution, and are connected to a screw-cup by compound rods passing through the cover. Zinc plates are suspended from the cover by connecting rods. These plates are provided with troughs or cups to contain mercury, to keep up the supply so as to maintain a uniform and constant amalgamation of the plates.

3621. "Telegraphic and telephonic apparatus." H. H. LAKE. (Communicated from abroad by F. van Rysselberghe, of Belgium.) Dated July 24. 6d. This invention relates to a system of Duplex telegraphy or of simultaneous telegraphy and telephony, which system is based upon the two following principles, that is to say:—1. When sudden currents are caused to pass through a telegraphic wire (currents, for example, which are produced by putting the said wire in direct communication with a battery by means of a Morse manipulator), a telephone, intercalated either directly or by means of a branch in the circuit of this wire, or an adjacent parallel wire, produces an intense sound at each emission, and at each interruption of the current, which

proves that, at the commencement and at the end of each emission, the electric flow is intermittent; because, if it was continuous and regular, the membrane or diaphragm in the telephone would merely yield but not vibrate. But if, instead of sending sudden currents gradual currents are sent, that is to say, currents which, at each emission, increase in intensity gradually up to a constant maximum, afterwards decreasing gradually until they are entirely or partially extinct, the membrane or diaphragm in the telephone merely yields without vibrating, and therefore produces no more sound on the passage of the current, or it produces a very feeble sound, which proves that, in this case, the electric flow is no more intermittent but sensibly continues. 2. Let c^1 c^2 (see fig. 1) be two condensers of slight capacity (a quarter of a microfarad is sufficient) established in derived or branch circuits



at the extremities, A and B, of a telegraph wire, and respectively connected to a telephone transmitter, T^2, and to a telephone receiver, T^1; and let R^1 and R^2 be two other derived or branch circuits (but direct ones, that is to say, without any condensers being inserted, the resistance of which is not less than five hundred (500) ohms. The derived or branch circuits, R^2, R^1, may then be suppressed or established during the telephonic conversation without any diminution being perceived in the intensity of the sounds received by the telephone, and this being still the case when the telephone receiver has a resistance greater than two thousand (2,000) ohms. If, therefore, in fig. 1, R^1 and R^2, are two telegraphic installations employing gradual currents, their working cannot in any manner obstruct the operation of the telephone, and, *vice versa*, the installation of this telephone does not interfere with the telegraph, as the currents used for the latter cannot branch off through the condensers. Two distinct services can thus be established entirely independent of each other, but capable of being operated by a single wire.

3632. "Preparing insulated wires." H. E. NEWTON. (Communicated from abroad by A. A. Cowles, of America.) Dated July 24th. 6d. Relates to improvements on an invention for which Letters Patent have been granted to the present applicant, dated February 28th, 1883, No. 1,093, and which relates to an electric conductor, in which the covering of braided or wound threads or strips of material are saturated and caused to adhere together by paint applied to the surface of one layer, and upon which the second layer of fibrous material is applied before the paint dries or sets, so that the paint is pressed into the first layer by the second layer, and oozes through the second layer, and thereby the braiding is rendered fireproof and the wire insulated. The object of part of the new invention is to lessen the risk of possible injury, and such part of the invention consists in applying to the surface of the wire a coating of waterproof non-conducting material, such as asphalte, or India rubber, mixed with asphalte and linseed oil, to which the first covering is applied directly, so as to adhere, and thereby moisture is entirely excluded.

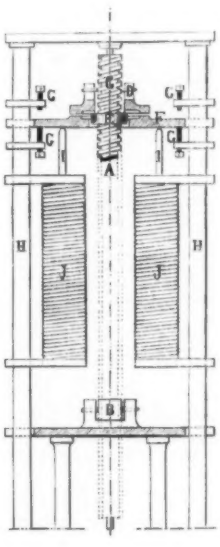
3633. "Machines for obtaining electric currents." E. JONES. Dated July 24th. 6d. The object of the present invention is to construct an electric generator which shall be compact and durable, and which, while run at a comparatively low speed, will yield a maximum amount of current, and to this end the invention relates more particularly to improvements in the construction of the armature, and in the method of winding the same, whereby the maximum amount of wire may be efficiently disposed thereon. The invention also relates to improved means for securing the armature upon the shaft of the machine, whereby great rigidity and stiffness are obtained. The invention also relates to means for accurately adjusting the position of the armature with respect to the field magnets disposed around its periphery. The invention further relates to a simplified arrangement of conductors within the hollow portion of the shaft, and to improved means for insulating and securing such conductors in place therein, and for coupling up or connecting such conductors with the commutator plates, whereby facilities are afforded for drawing off the electric currents and distributing them.

3692. "System of electrical distribution." ST. GEORGE LANE FOX. Dated July 28th. 6d. The inventor employs generators for developing high tension currents, and operates them from the distant point or points which are to be the source or sources of energy as will be well understood. From these high tension generators he leads insulated conductors to the several districts where the energy is to be distributed and utilised, and which may be called sub-centres of distribution. At these sub-centres he employs electro-motors operated by the high tension currents, and connects with these motors generators for producing low tension currents. The motor and generator are by preference placed in the same frame, and act through one and the same shaft, this compound motor and generator being thus like a dynamo machine, but with two armatures fixed on the same shaft, the one armature being caused to rotate by means of the high tension currents, and thereby driving the shaft of the motor, while the other armature being fixed to this shaft rotates with it, and causes currents to be developed in the low tension system.

3702. "Dynamo-electric machines or electric generators." S. Z. DE FERRANTI and A. THOMPSON. Dated July 28th. 1s. 4d. In the construction of dynamo-electric machines in order to obtain safer insulation between the iron cores and the electric conductors wound around them, the inventors give to the sides of the cores a coating of enamel, or like insulating material, and if the cores are cast in one piece with the side frames, the inner face of the frame may also be similarly enamelled. When the electric conductors used for exciting the several magnets in each circle of magnets of a dynamo-electric machine are metallic bars wound in a zig-zag manner in and out between the magnet cores, they insulate the conductors from the cores by interposing between them rods of insulating material, and the several conducting stripes which lie side by side they insulate one from the other by small studs of insulating material carried in small corresponding depressions in the sides of the conducting strips, and made to project therefrom so as to keep the metallic bars at a distance the one from the other. When the conductor is wound separately in one continuous coil around each magnet core, the several coils may similarly be insulated one from the other and from the cores.

3735. "Electro-dynamic machines." H. J. ALLISON. (Communicated from abroad by R. N. King, of America.) Dated July 31. 4d. Relates to an improvement in electro-dynamic machines, the object of which is—first, to provide an armature the core of which is formed of a series of parallel iron wire rings each of which is wound in U shaped strips and suspended upon tie-rods, and at intervals apart from each other, which tie-rods are secured to discs or hubs, which are rigidly secured upon a revolving shaft and being further provided with a dia-magnetic core, which is preferably made of a series of wooden discs lying within the core rings, and secured to the shaft between the hubs to which the tie-rods are attached. (*Provisional only.*)

3779. "Regulating the movement of the carbons, &c. in electric lamps." E. G. BREWER. (A communication from abroad by La Société Anonyme des Ateliers de construction mecanique et d'appareils èlectriques, of Paris.) Dated August 2. 10d. The object of this invention is to regulate the movement of the light carbons in use in electric lamps with voltaic arc at a fixed or not fixed luminous point. This system essentially consists in the interposition of a friction appliance between the cores or movable armatures of the regulating electro-magnets traversed by the current, or by a derivation of this current, and the apparatus which determines either the regulation only or the regulation and the displacement of the carbons of a special friction appliance always ready to operate and to produce without loss of time to the carbon on which it is desired to act, the slightest movements being governed by the magnetic regulating apparatus of the lamp; this friction appliance being composed of soft ieces of



metal one of which is mounted on a screw thread, the other turning slightly under the pressure of the first; these two parts remain in contact one with the other even when they are not regulated, and as their complete solidity is simply produced under the action of a very slight excess of pressure regulated between them by the magnetic regulating apparatus. This system of regulation is applicable to all kinds of regulators for electric arc lamps; this improved system is applicable to all types of electric arc lamps, such for example as those where the movement of the carbons is regulated by means of cords and counter-weights or rack clock-work, or any suitable motor. The figure represents the application of the invention to a lamp of this system with a

moveable burner; A is the central vertical screw with elongated or quick threads arranged to turn freely between two fixed pivots, the object of which is to soften and regulate the movement of the upper carbon suspended to the nut, B, which in its descent communicates to this central screw, A, a rotary movement. In order to utilise this screw as a means of regulating by adapting to it the system which is the object of the present invention, that is to say, to suspend the movement of the descent of the nut, B, or even to reverse the direction of the rotation of this screw, A, and thus to determine the backward movement of one of the carbons; the inventor forms at a certain part of this central screw a collar, E, which divides the thread into two divisions of which C is the upper portion and A the lower; the thread of the screw of these two divisions may be of the same or different pitch if thought preferable. On the upper division, C, of the thread is placed a second nut, D, called the regulating nut in opposition to the moveable nut, B, on the lower divisions of the screw, A, which may be called the motor nut. It being understood that the regulating nut, D, is arranged so as to be perfectly moveable on the upper division of the central screw, C, in such manner that when in its normal position it comes down by its own weight and rests on the collar E, before referred to. At a level somewhat lower than that of the collar, E, is placed a plate, F, held between regulating tappets, G, or set screws fixed to the columns, H, of the lamp support or framework, and which limit to a few millimeters the displacement of the plate, against the underside of which plate, F, the prolongations of the cores, I, of the regulating bobbins, J, of the lamp act. Under these conditions a slight displacement of cores, I, of the bobbins is sufficient to raise the plate, F, a sufficient distance for it to come in contact with the lower face of the regulating nut, D, which till then rested on the collar, E, and consequently turned with it but by the effect of the friction of the nut, D, on the plate, F, the regulating nut, D, is immediately arrested in its rotary motion and stops the central screw, A, C, and consequently the descent of the motor nut, B, then if the plate, F, continues to be slightly raised it will cause the division of central screw, C, on which it rests to turn in the opposite direction to that when it was moved by the action of the screw, B, and descending under the weight of the lower carbon; this nut, B, not being able to turn is then raised and will thus distance the carbons from one another. As soon as this movement is sufficient for the current to recover its normal intensity the regulating bobbins, J, will cease to raise the core rods, I, and the plate, F, by lowering will allow the regulating nut, D, to descend and again to rest on the collar, E, and to turn with it leaving the central screw, A, C, free to move by the action of the motor nut, B, that is to say, in the direction which determines the approach of the carbons. It is to be understood that during the operation of the lamp these successive actions of the motor nut and of the regulating nut, instead of taking place at long intervals, may be accomplished at very short ones; that is to say, that the regulating nut, D, when the position of the plate, F, has been regulated will be constantly in slight contact at the same time with the plate, F, and the collar, E, in this manner a very slight action of the rods, I, will be sufficient to produce very slight variations between the pressures produced by one or the other of these pieces on the regulating nut, D, which will adhere by its friction with one of them from which it will receive a greater reaction, the regulation will be then obtained between very short limits which will assure under all circumstances, perfect uniformity of the light, which is required.

CORRESPONDENCE.

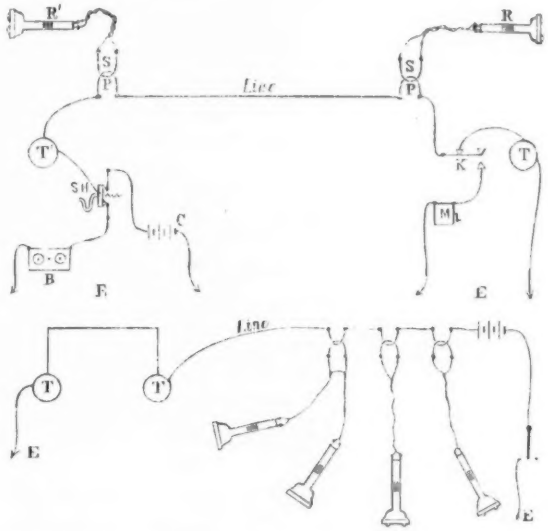
Telephonic Applications.

The telephone is adapted to so many purposes that perhaps it is less possible to lay down comprehensive rules for its application than for almost any other form of apparatus. Speaking generally, however, it is found that the arrangements of instruments answer best which rely the least on the skill or memory of "subscribers" and others who have the manipulation of them, and leave the least exposed to inquiring minds and active fingers.

The transmission by telephone of speeches, sermons, music, &c., to a distance has at different times been under my care, and as it is an application which will probably be largely availed of in the future, a description of the arrangements found to answer best may prove of use to others.

One or two cases will be sufficient for illustration. The small battery connected to a Blake transmitter, fixed in the pulpit of a church, to transmit the sermon, &c., along a short line to the room of an invalid required attention much more often than appeared necessary, and it was found that this was due to the sexton occasionally neglecting to turn the switch after the service.

As this inconvenience could not be permitted to continue, the battery was then taken to the other end of the line, and connected so as to be placed in or out of circuit with the distant transmitter by the operation of the automatic switch-hook on which the invalid's receiver hung when not in use. The following diagram further explains:—



S and P are respectively the primaries and secondaries of the induction coils at each end of the line. T and T¹ the microphone transmitters. R and R¹ the receivers. C is the battery of two or more cells, according to the length of the line, which is connected to it and the transmitters in circuit when R¹ is taken off the automatic switch-hook, S, H. M, a small magneto-generator or battery, by means of which and the key, K, the bell, B (in circuit with the line when R¹ is on the hook), is rung to call the invalid's attention when desired. These are not very necessary, as the time at which the service commences is known.

I have used a similar arrangement to transmit to a distance the dialogue, &c., of dramatic performances. A Blake microphone was placed at each wing, and connected to the line in the manner shown below. Several persons heard the performance, each holding a receiver connected to the secondaries of induction coils, the primaries of which were on to the battery, C, and the line. The very unusual method of connecting gave good "speaking" results in both of the above cases.

Compared with other electric industries, telephony is one which is seldom discussed through the medium of the press, although opinions vary very widely as to the best arrangements for the different points of exchange and private line systems. We have, it is true, been entertained with lengthy communications on the patents question, but probably the principle object, which I take to be improvement and advancement, would have been better served by a more frequent reference to practical details.

Wm. L. Madgen,

Belfast, *March 26th*, 1884.

The New Patent Act.

I apprehend that the meaning of Section 113 of the New Patent Act in its bearing on the repeal of Section 25 of the Patent Law Amendment Act of 1852, is that the new act shall not operate to resuscitate any British patent which had previously to January 1st 1884, lapsed through the avoidance of a foreign patent of prior date to such British patent. I do not see what other interpretation the words which Mr. Strangeways quotes can have, considering the existence of Section 45 of the new Act.

Thos. J. Handford.

42, Southampton Buildings,
March 31st.